



Missouri Department of Natural Resources

Biological Assessment and Fine Sediment Study Report

Bryant Creek (WBID 2535), Douglas County

Fall 2019 – Spring 2021

Prepared for:

Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

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1.0 Introduction

Bryant Creek is located in southern Missouri approximately 50 miles southeast of Springfield. The stream flows from near Mansfield, Missouri, for approximately 62 miles through the Ozark/White Ecological Drainage Unit (**EDU**) before reaching its confluence with Norfolk Lake in northern Arkansas (Figure 1).

The Bryant Creek reach included in this study (WBID 2535) is classified as a class P stream that flows from north to south through the center of Douglas County, Missouri (Figure 2). Drainage areas range from 42.9 to 191.4 square miles for stations included in this study. Major tributaries of Bryant Creek within this area include Dry Fork, Bill Macks Creek, Hunters Creek, and Rippee Creek. Bryant Creek flows through two Missouri Department of Conservation (**MDC**) areas, and the Missouri Department of Natural Resources' Bryant Creek State Park is approximately 2.5 miles downstream from the study area. Bryant Creek has beneficial use designations that include irrigation (**IRR**), livestock and wildlife protection (**LWP**), protection of warm water habitat (**WWH**), cool-water habitat (**CLH**), whole-body contact (**WBC**) – category A; and secondary contact recreation (**SCR**).

The approximately 1.5 miles of Bryant Creek flowing through MDC's Rippee Conservation Area (**CA**) is listed as an Outstanding State Resource Water (MoDNR 2018d, Table E). The Rippee CA includes the Bryant Creek Natural Area, which makes up the left descending bank riparian corridor through much of the CA. Although the entire study reach is classified as warm water, a 6-mile segment of Bryant Creek just upstream of the study reach is designated as a cold-water fishery (MoDNR 2018d, Table C; Figure 2).

1.1 Justification

The Bryant Creek watershed in Douglas County includes animal grazing, wastewater inputs, stormwater runoff, and gravel mining that could affect the aquatic community (Appendix E and F). To date, the quality of stream habitat, its aquatic community, and water quality have not been assessed through a comprehensive study of Bryant Creek.

A gravel mining operation in the study area is authorized by Missouri State Operating Permit Number MO-G500190 for process wastewater, mine dewatering, and stormwater discharges associated with sand and gravel mining/dredging, processing, and stockpiles. Part of the overall assessment in this reach of Bryant Creek included measuring turbidity values and benthic fine sediment coverage to determine if there are differences in water clarity and sediment deposition among sampling locations.

Bryant Creek was examined to determine its ability to support the “protection of warm-water habitat” (**WWH**) beneficial use designation. This study included stream habitat assessment, biological assessment (including macroinvertebrate community and physicochemical water quality analyses), water quality data logger deployment, and a benthic fine sediment estimation study. This biological assessment study was requested by the MoDNR Water Protection Program

(WPP) and was conducted by the Division of Environmental Quality (DEQ), Environmental Services Program (ESP), Water Quality Monitoring Section (WQMS). Laboratory water quality analyses were conducted by the MoDNR, ESP Chemical Analysis Section (CAS).

1.2 Study Objectives

- Assess stream habitat quality.
- Assess the “protection of warm water habitat” designated beneficial use status using the benthic macroinvertebrate community.
- Evaluate the physicochemical water quality.
- Evaluate long-term temperature, specific conductance, and turbidity conditions.
- Measure the relative benthic fine sediment coverage and determine its size class.
- Identify potential influences.

1.3 Null Hypotheses

- 1) Stream habitat quality at all streams will be comparable to the stream habitat control.
- 2) Macroinvertebrate Stream Condition Index (MSCI) scores will indicate that Bryant Creek stations are fully supporting of the WWH beneficial use, and individual biological metrics will be within the optimum scoring range of wadeable/perennial reference stream biological criteria during the fall and spring seasons.
- 3) Physicochemical water quality constituents will be within acceptable limits as specified in Missouri’s Water Quality Standards (WQS; MoDNR 2018d) and will not be otherwise notable.
- 4) Data logger water quality constituents will be similar among stations throughout deployment.
- 5) Benthic fine sediment coverage and size classes will be similar among stations.

2.0 Methods

Kenneth B. Lister, Brandy Bergthold, Carl Wakefield, Rory Mott, and other ESP personnel were involved in this study. Study timing is outlined in this section. The study area, station locations, station descriptions, Ecological Drainage Units, and land uses are provided. Stream habitat assessment methods are discussed. Biological assessment procedures are described for macroinvertebrate and physicochemical water collection and analyses. Data logger and fine sediment estimation methods are provided in this section.

2.1 Study Timing

Sampling was conducted in fall 2019 and spring 2021 (Table 1). Sampling is usually conducted in fall and spring in consecutive years. However, due to COVID–19 travel restrictions in 2020, the spring season was delayed by one year. Stream habitat assessments were conducted in September 2019. Macroinvertebrate and water samples were collected at all stations in mid-September 2019 and mid-April 2021. Fine sediment estimations were conducted in July 2019. Data loggers were deployed at all stations on October 9, 2019, and retrieved on October 23, 2019.

Table 1
 Field Sampling Schedule (Month-Day) in Fall 2019/Spring 2021

Stream Station Number	SHAPP	Macroinvertebrate	Water Quality	Fine Sediment Estimation
BC 38.7	9-17-19	9-18 / 4-14	9-18 / 4-14	7-31-19
BC 35.2	9-18-19	9-18 / 4-14	9-18 / 4-14	7-30-19
BC 32.6	9-18-19	9-18 / 4-14	9-18 / 4-14	7-30-19
BC 27.6	9-9-19	9-17 / 4-15	9-17 / 4-15	7-31-19
BC 23.27	9-9-19	9-17 / 4-14	9-17 / 4-14	7-30-19
Bull Creek 10.1*	9-4-19	--	--	--
NFWR*	9-23-19	--	--	--

BC = Bryant Creek; * = SHAPP Control; -- = not sampled; NFWR = North Fork White River.

2.2 Study Area, Station Locations, and Descriptions

The study area was located approximately 10 miles east of Ava, Missouri. Five stations were allocated for the study, covering approximately 16 miles of Bryant Creek (Figure 2). Station identification numbers are based on their location in stream miles upstream of the WBID's downstream terminus. Stations were positioned to assess conditions and identify areas in Bryant Creek (BC) that may have water quality issues. Station descriptions are provided in Table 2.

The length of each station was approximately 20 times the average width of the stream, consistent with the *Semi-Quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP; MoDNR 2019c)*. Each station contained at least two riffle sequences. Rabeni et al. (1999) found this station length to be adequate for sampling macroinvertebrate communities, and a single reach can be representative of an entire stream segment.

2.2.1 Ecological Drainage Unit

The Bryant Creek study area is located in the Ozark/White EDU (Figure 1). An EDU is an area that is delineated by its natural terrestrial physiographic division and major riverine watershed components. EDUs are described in detail by Sowa et al. (2007). Streams of similar size within an EDU are expected to provide similar habitat conditions and biological communities. As such, stream habitat, biological communities, and physicochemical components should be comparable between test streams and reference streams within the same EDU.

2.2.2 Land Use Descriptions

Land uses in close proximity to Bryant Creek stations were compared among stations and with the EDU (Table 3). Land use categories were identified for each station based on their associated 12-digit Hydrological Unit Code (HUC-12). Land use data were derived from Thematic Mapper satellite data collected between 2000 and 2004 and interpreted by the Missouri Resource Assessment Partnership (MoRAP).

Land use was generally similar among stations and with the EDU (Table 3). Forest land cover was the most prevalent land use at all stations and the EDU, followed by grassland and woody/herbaceous land use. The remaining land uses made up < 1 percent of the watershed

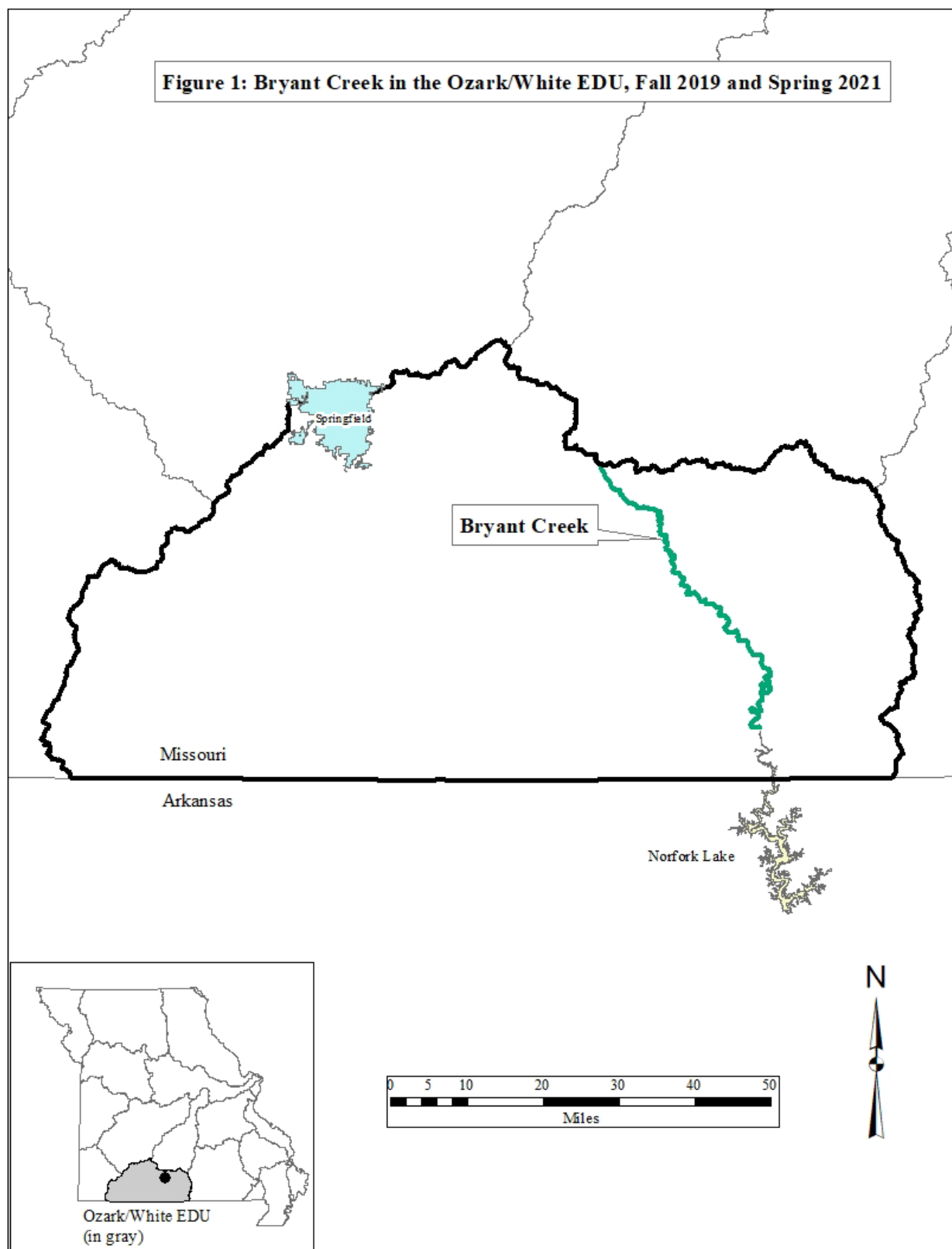
within the HUC-12 boundaries. These remaining land uses were also minor components of the EDU, but they had slightly higher percentages compared to Bryant Creek sample stations.

Although major land uses were similar among all stations and the EDU, they followed trends that may more closely describe conditions adjacent to the stream at points from upstream to downstream (Table 3). Forest cover increased from upstream to downstream and was most prevalent at the two downstream stations owned by MDC (Vera Cruz CA and Rippee Creek CA). As forest cover increased from upstream to downstream within the study area, grassland decreased by nearly half. Animal grazing was observed more frequently upstream than downstream, and outdoor recreation areas were more prevalent at downstream stations.

Table 2
 Locations and Descriptions of Bryant Creek (BC) and SHAPP Control Stations,
 Fall 2019 and Spring 2021

Station	County	Location	Description	WBID	Purpose
BC 38.7	Douglas	NW¼ sec. 30, T. 27 N., R. 14 W. UTME 542702; UTMN 4096061	DS Hwy U; Upstream Station	2535	Test
BC 35.2	Douglas	SW¼ sec. 31, T. 27 N., R. 14 W. UTME 542548; UTMN 4092785	US CR 114; DS Tributaries	2535	Test
BC 32.6	Douglas	NE¼ sec. 07, T. 26 N., R. 14 W. UTME 543550; UTMN 4090073	US Hwy 76; DS - J&R Sand/Gravel	2535	Test
BC 27.6	Douglas	NW¼ sec. 29, T. 26 N., R. 14 W. UTME 544921; UTMN 4085471	DS CR 223, MDC Vera Cruz CA	2535	Test
BC 23.27	Douglas	NW¼ sec.10, T. 25 N., R. 14 W. UTME 547031; UTMN 4080593	DS CR 326, MDC Rippee CA	2535	Test
Bull Creek 10.1	Christian	SW¼ sec. 36, T. 25 N., R. 21 W. UTME 483666; UTMN 4074536	DS Dry Hollow Rd.	2423	SHAPP Control
N.F.White River 19.7	Douglas	SE¼ sec. 12, T. 26 N., R. 12 W. UTME 570810; UTMN 4089190	DS CR E276 0.2 mile	2507	SHAPP Control

WBID = Water Body ID; Hwy = Missouri highway; CA = Conservation (MDC) Area or Access; CR = County Road; DS = downstream; US = upstream; SHAPP = Stream Habitat Assessment Project Procedure (MDNR 2016); Tributaries = Bill Macks and Dry Fork



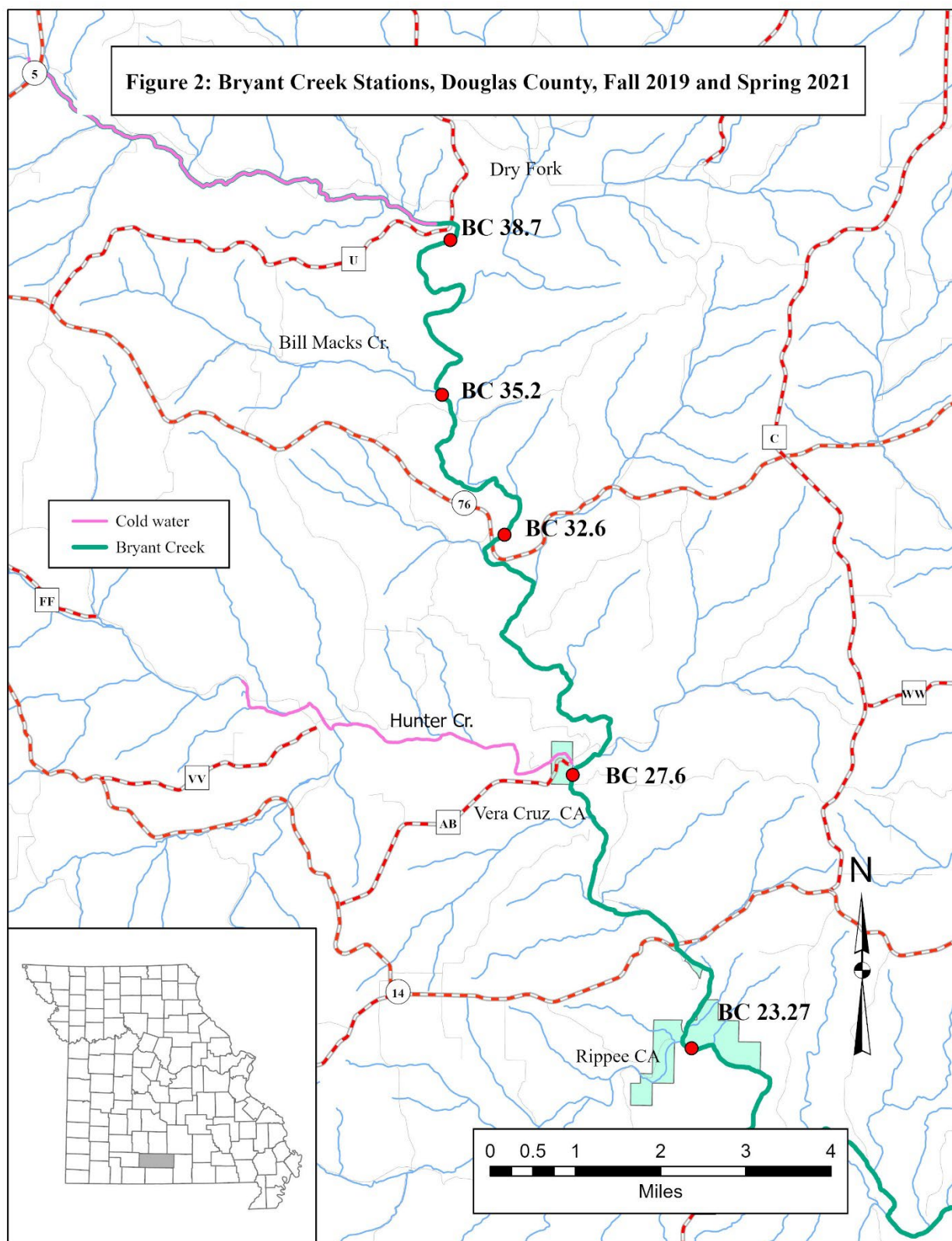


Table 3
 Percent Land Use/Cover for Bryant Creek (BC) Stations, Douglas County by
 Hydrologic Unit Code – 12 (HUC-12), and the Ozark/White EDU

Stations/Land-Use HUC-12 110100060-	BC 38.7 -302	BC 35.2 -304	BC 32.6 -304	BC 27.6 -305	BC 23.27 -305	Ozark/ White EDU
Impervious	0.79	0.13	0.13	0.40	0.40	1.50
Urban	0.53	0.24	0.24	0.24	0.24	1.93
Barren and Sparse	0.43	0.84	0.84	0.70	0.70	1.53
Crop	0.71	0.63	0.63	0.55	0.55	1.28
Grassland	34.02	26.74	26.74	19.08	19.08	37.19
Forest	56.19	64.62	64.62	72.53	72.53	48.04
Woody/Herbaceous	7.06	6.26	6.26	5.45	5.45	5.95
Wetland	0.008	0.005	0.005	0.007	0.007	0.10
Open-water	0.22	0.45	0.45	1.00	1.00	2.50

HUC-12 Codes: 302 – Headwaters Bryant Creek; 304 - Tarbutton Creek; 305 - Rippee Creek

2.3 Stream Habitat Assessment Project Procedure

The *Stream Habitat Assessment Project Procedure (SHAPP)* was followed as described for riffle/pool prevalent streams (MoDNR 2016). According to the SHAPP, stream habitat can affect the quality of the biological community. Stream habitat quality of test stations is compared to the habitat quality of a control stream (SHAPP control). Stream habitat features are given numeric scores based on visual assessments at test stations and SHAPP controls. The SHAPP score for each test station is then expressed as a percentage of the SHAPP control. If the SHAPP score for a test station is $\geq 75\%$ of the control score (mean score in the case of multiple control sites), the stream habitat at that test station is considered to be comparable to the SHAPP control. Bull Creek 2423_10.1 in Christian County and North Fork White River 2507_19.7 in Douglas County served as SHAPP controls for this study (Table 4).

2.4 Biological Assessment

This biological assessment was conducted using methods described in the SMSBPP (MoDNR 2019c). A biological assessment includes examination of the macroinvertebrate community and physicochemical water quality of test streams. Primary metrics are used in the assessment to describe the macroinvertebrate community structure compared to reference quality communities. Water quality constituents are examined for trends, notable results, and compared to Missouri's Water Quality Standards (MoDNR 2018d), as well as other available thresholds. Biological assessments are grouped by year (season) and station.

2.4.1 Macroinvertebrate Sampling, Identification, and Analyses

Macroinvertebrate samples were collected from multiple habitats, as described in the SMSBPP (MoDNR 2019c). Bryant Creek is a riffle/pool dominant stream. As such, coarse substrate (**CS**; riffle), non-flowing water over depositional substrate (**NF**; pool), and rootmat (**RM**) habitats were sampled. In the WQMS laboratory, macroinvertebrates were acquired from subsamples of the benthic material collected for each habitat and identified to specific taxonomic levels (MoDNR 2019d). Primary metrics generated from these macroinvertebrate data are used to

calculate the Macroinvertebrate Stream Condition Index (**MSCI**). Ultimately, this MSCI and the narrative will describe Bryant Creek's ability to support the protection of warm water habitat designated beneficial use.

A stream condition index using macroinvertebrates was developed as a measure of a stream's biological integrity (Rabeni et al. 1997). The index was further refined to include biological criteria that were generated using wadeable/perennial biological reference streams (**BIOREF**) for each EDU, as described in *Biological Criteria for Perennial/Wadeable Streams* (MoDNR 2002). Now called the Macroinvertebrate Stream Condition Index (MSCI), this semi-quantitative rank score is derived by comparing test station metric values to BIORREF criteria.

An MSCI score is based on a multi-metric assessment of the macroinvertebrate community composition (Tables 5 and 6). The four primary biological metrics used to calculate the MSCI are 1) Taxa Richness (**TR**), 2) Ephemeroptera/Plecoptera/Trichoptera Taxa (**EPTT**), 3) Biotic Index (**BI**), and 4) Shannon Diversity Index (**SDI**). Each metric value is compared to BIORREF criteria. Metrics then receive individual scores of 5, 3, or 1 based on where the values fall within the BIORREF criteria scoring range. The MSCI score is the sum of all four individual metric scores. The MSCI score is then placed in one of the following biological support categories: 20-16 = fully supporting; 14-10 = partially supporting; and 8-4 = non-supporting of the beneficial use designation. MSCI scores were examined by station and grouped by season (Tables 5 and 6).

A complete taxa list is provided in Appendix D. The *Macroinvertebrate Database Bench Sheet Report* may be used to further examine species occurrence. The bench sheet report is grouped by season and station.

2.4.3 Physicochemical Water Sampling and Analyses

Physicochemical water samples were collected and analyzed according to applicable MoDNR, ESP Standard Operating Procedures (**SOPs**). Physicochemical water quality results were examined by year and station.

Physicochemical water constituents were measured in the field or analyzed at the ESP State Environmental Laboratory in Jefferson City, Missouri. Water was sampled according to SOP MDNR-ESP-001 *Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations* (MoDNR 2018c). Temperature (°C), pH, specific conductance (µS/cm), dissolved oxygen (mg/L), and discharge (cubic feet per second-**cfs**) were measured *in situ*. The ESP's CAS conducted analyses for ammonia as nitrogen (**NH₃-N**), nitrate+nitrite as nitrogen (**NO₃+NO₂-N**), total nitrogen (**TN**), chloride (**Cl**), sulfate (**SO₄**), total phosphorus (**TP**), and non-filterable residue (**NFR**). Turbidity (nephelometric turbidity units, **NTU**) was measured and recorded at the WQMS biology laboratory. All samples to be analyzed at ESP were kept on ice during transport.

Surface water physicochemical results were compared to Missouri's Water Quality Standards (MoDNR 2018d) and suggested guidelines, or they were highlighted if results were notable. Because Missouri does not currently have nutrient criteria for streams and rivers, nutrient values were compared to guidelines suggested in *Ambient Water Quality Criteria Recommendations for*

Rivers and Streams in Nutrient Ecoregion XI (EPA 2000). The EPA *Aggregate Nutrient Ecoregion XI, level III (sub)ecoregion 39* recommended reference condition values used for comparison were as follows: $\text{NO}_3+\text{NO}_2\text{-N}$ (0.239 mg/L), turbidity (1.425 NTU), TN (0.379 mg/L), and TP (0.006625 mg/L).

The EPA suggested guidelines listed above contain scientific recommendations regarding ambient concentrations for nutrients; they do not substitute for Clean Water Act or EPA regulations, nor are they state regulations. The criteria were empirically derived to represent conditions of surface waters that are minimally affected by human activities and protective of aquatic life and recreational uses (EPA 2000).

2.4.4 Discharge

Stream discharge was measured using a Marsh-McBirney Flo-Mate™ Model 2000 flow meter at each station. Velocity and depth measurements were recorded at each station, and discharge was calculated according to SOP MDNR-ESP-113 *Flow Measurement in Open Channels* (MoDNR 2015).

2.5 Data Logger Deployment

Data loggers (also referred to as “sondes”) were deployed to measure several water quality constituents over a period of time. YSI Environmental Monitoring Systems – 6920 V2 Multiparameter Water Quality Sondes were deployed to measure temperature (°C), specific conductance ($\mu\text{S}/\text{cm}$), and turbidity (Formazin Turbidity Units – FNU). The sondes sampled each parameter at 10-minute intervals for approximately two weeks, which amounted to over 2000 measurements being recorded. Descriptive statistics were examined for all three constituents (Appendix A), and statistical analyses were conducted on turbidity data (Appendix B).

Statistics – Turbidity Data

Statistical analyses were conducted on turbidity sonde data using SigmaStat Version 3.5 (SigmaStat 3.5 for Windows 2006). One Way Analysis of Variance (ANOVA) and Kruskal-Wallis One way ANOVA on Ranks was used to determine whether there was a significant difference ($p<0.05$) in turbidity levels among BC stations (Appendix B). All Pairwise Multiple Comparison Procedures methods (Holm-Sidak [ANOVA]; Dunn’s [ANOVA on Ranks]) were used to identify where differences occurred among stations. Because we were not confident in the quality of the turbidity data at two sites, readings from these sondes were not included in statistical analysis. During retrieval, one sonde was found buried under 2 feet of gravel (BC 27.6), and the wiper was bound by rocks on another sonde (BC 23.27).

2.6 Fine Sediment Coverage and Size Classes

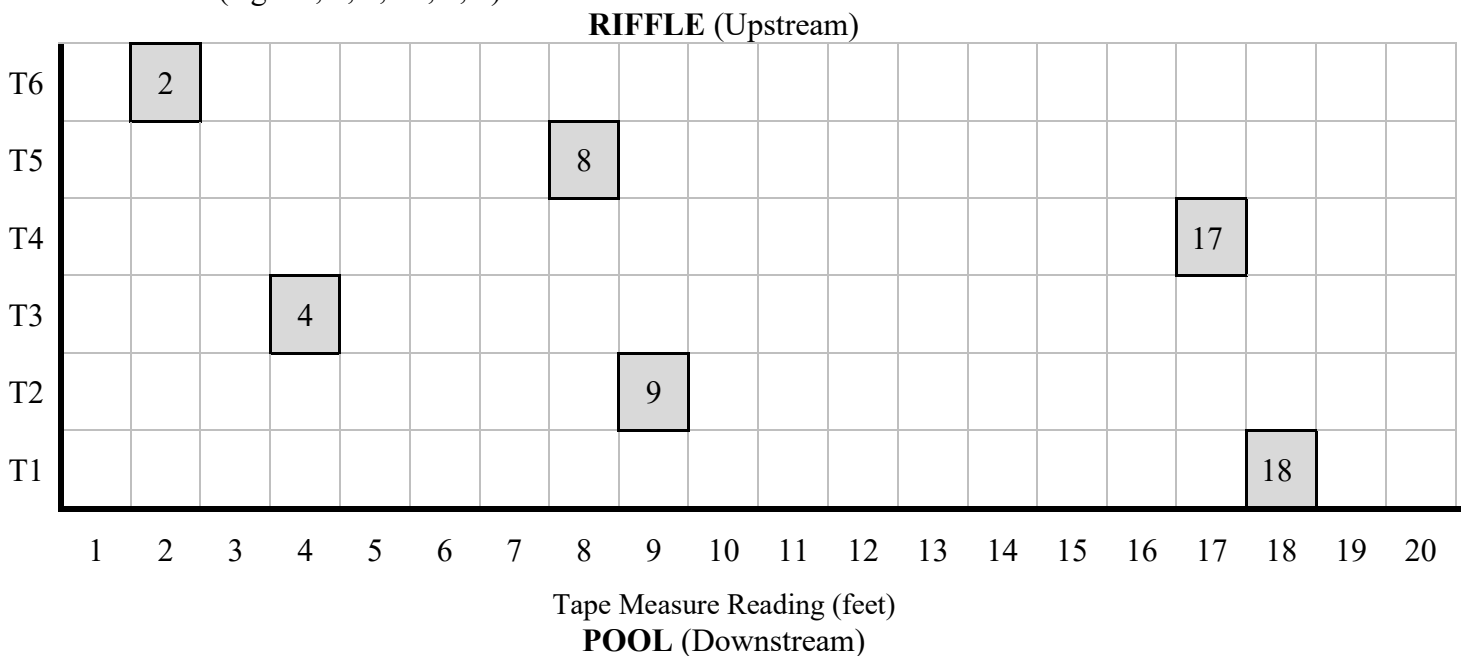
Benthic fine sediment coverage was estimated in BC according to MDNR-ESP-115 *Estimation of Benthic Fine Sediment Coverage in Wadeable Streams* (MoDNR 2019a). Instream deposits of fine sediment (i.e. particle size <2 mm) were visually estimated for relative percent coverage per station. Two observers made visual estimates, and the mean of the two values was recorded.

Visual estimates were conducted within a 0.25 m² metal quadrat that was randomly placed in sample grids (Figure 3). Each station contained three grids. This method allowed for accurate and consistent comparisons of the relative coverage of benthic fine sediment within and among stations, as well as identification of dominant size-fraction.

To ensure sampling method uniformity, grids were located at the downstream margins of riffles or runs and the upstream margins of pool habitats in areas of relatively laminar flow with velocity ≤ 0.5 feet per second. According to the Hjølstrom Diagram for threshold transport and settling velocities (Hjølstrom 1939), this velocity allows fine sediment-sized particles to settle from transport after high flow events. A Marsh-McBirney flow meter was used to measure water velocity. Depths did not exceed 3 feet. Grids excluded eddies, bends, and areas downstream of vegetation or large obstructions that may cause turbulent flow. These considerations were made to minimize errors in fine sediment coverage estimates.

Statistical analyses were conducted on fine sediment coverage and size fraction data using methods described in Section 2.5. Two-Way ANOVA was used to identify differences in fine sediment size fractions (i.e. silt and sand) within and among stations.

Figure 3: Virtual grid of transects (T) and quadrats (e.g gray boxes) used to estimate percent fine sediment coverage. Example: stream 20 feet wide; quadrat placement was based on random numbers (e.g. 18, 9, 4, 17, 8, 2).



2.8 Quality Control

The quality assurance process for this biological assessment study is outlined in the FY 2020 Quality Assurance Project Plan (**QAPP**; MoDNR 2019b), SOP MDNR-ESP-210 *Quality Assurance/Quality Control for Environmental Data Collection* (MoDNR 2018b), the SHAPP

(MoDNR 2016), and the SMSBPP (MoDNR 2019c). A duplicate macroinvertebrate sample was collected at one station among this team's field assignments during each sample season.

Duplicates were compared using the Quality Similarity Index (**QSI**) to assess sampling consistency between collectors and accuracy in taxa identification. Duplicate surface water samples were collected and analyzed for at least every 10 samples to assess consistency and accuracy in collection and analyses (MoDNR 2018b). The acceptable Relative Percent Difference (**RPD**) between water sample variables should be ≤ 20 percent according to the QAPP. No duplicate macroinvertebrate or water samples were collected at BC.

Sonde Deployment Quality Control

The quality control protocol for sonde data collected during deployment is outlined in MDNR-ESP-104 *Continuous Monitoring of Water Quality using a Dissolved Oxygen, Specific Conductance, pH, Turbidity, Rhodamine Dye, and Temperature Data Logger* (MoDNR 2018a). Side-by-side measurements were collected *in situ* for temperature, specific conductance, and turbidity for each sonde using a YSI ProDSS handheld meter. Measurements were recorded for all constituents 10 minutes after deployment and at corresponding times before retrieval of the sondes. The RPD between the sonde and handheld meter measurements were compared to acceptable limits that are outlined in the QAPP FY2020 (MoDNR 2019b). Acceptable limits for data sonde variables are: temperature ± 0.3 °C; specific conductance ± 10 percent; and turbidity ± 5 percent of measured value.

Fine Sediment Estimation Quality Control

Quality control for fine sediment estimations is outlined in the SOP *Estimation of Benthic Fine Sediment Coverage in Wadeable Streams* (MoDNR 2019a). Independent observations by two analysts decrease potential for bias and increase accuracy. Estimates recorded by the two analysts must be within 10 percent of each other for accuracy and consistency.

3.0 Results and Discussion

Stream habitat assessments, biological assessments (including macroinvertebrate community and water quality analyses), long-term water quality monitoring using data loggers, and fine sediment coverage estimations are included in this section. Results are grouped by season and station. Notable results and trends are highlighted.

3.1 Stream Habitat Assessment

Stream habitat scores at all BC stations exceeded the 75 percent similarity threshold necessary to be considered comparable to the average of the SHAPP control stream scores (Table 4). The most upstream station (BC 38.7) had the lowest score (120), reaching 80 percent of the SHAPP control. The three middle stations (BC 35.2, BC 32.6, BC 27.6) were ≥ 90 percent of the SHAPP controls. The most downstream station (BC 23.27), located in MDC's Rippee CA, attained the highest SHAPP score (148), reaching 98 percent of the SHAPP controls.

Table 4
 Stream Habitat Assessment Project Procedure (SHAPP) Scores (20 points possible for each
 Feature) for Bryant Creek Stations: Comparisons with SHAPP Control Streams
 (Bull Creek #10.1; North Fork White River #19.7)

Habitat Assessment Features	BC 38.7 Hwy. U	BC 35.2 CR 114	BC 32.6 Hwy.76	BC 27.6 Vera Cruz CA	BC 23.27 Rippee CA	Bull Cr 10.1	NFWR 19.7
Epifaunal Substrate	18	17	17	17	16	19	16
Embeddedness	18	17	18	18	18	17	17
Velocity/Depth Regime	10	18	19	20	20	15	19
Sediment Deposition	15	12	10	9	6	15	5
Channel Flow Status	8	14	9	15	14	9	15
Channel Alteration	19	18	16	20	19	20	20
Riffle Quality	16	17	19	18	15	15	17
Bank Stability L/R (10 points)	2/10	9/8	9/9	1/9	9/10	9/10	6/10
Vegetative Protection L/R (10 Points)	1/1	1/1	1/1	1/1	1/1	2/1	1/5
Riparian Vegetation L/R (10 Points)	1/1	1/7	9/0	3/4	10/9	9/9	10/10
Score	120	140	137	136	148	$\bar{X} = 150.5$	
Percentage of SHAPP control	80	93	91	90	98	--	

Bold = Below 50 percent of possible score; L = Left bank, R = Right bank; Bull Creek and North Fork White River (NFWR) = SHAPP Controls; CR = county road; Hwy = highway.

Notable stream habitat features are those that reduced SHAPP scores at each BC station (Table 4). Although Vegetative Protection was scarce at all BC stations, it was also limited at the SHAPP controls, so it is not given further consideration as an influential stream habitat feature. The BC 38.7 score was reduced due to a narrow and shallow channel that affected the Channel

Flow Status feature. In fall, flow disappeared into a thick alluvial layer in the downstream half of the station. Poor Bank Stability on left bank of BC 38.7 and sparse wooded Riparian Vegetation on both sides also contributed to the lower score. The BC 35.2 score was affected by little wooded Riparian Vegetation on the left bank. BC 32.6, located downstream from J and R Sand and Gravel, had a braided and extremely wide (approximately 300 feet) channel that had a substantial influence on Channel Flow Status. This station also had no wooded Riparian Vegetation on the right bank. Despite the riparian corridor conditions, both banks were stable at BC 32.6. At BC 27.6 (Vera Cruz CA), fine Sediment Deposition was prevalent, the left bank was not stable, and there was little wooded Riparian Vegetation on both sides of the stream. The SHAPP score at BC 23.27 (Rippee Creek CA) was reduced by substantial Sediment Deposition downstream from the Rippee Creek confluence. Riparian vegetation was poor at four of the five stations.

3.2 Biological Assessment

Biological assessments consist of macroinvertebrate community biological metric analyses and water quality analyses. Notable results for BC are grouped by season and station.

3.2.1 Macroinvertebrate Community Analyses: Primary Metrics

Primary metrics, including MSCI scores and biological support categories, were identified for all BC stations. The relative contributions of individual metrics to MSCI scores were interpreted to identify influences or areas of interest in the study reach. Results are grouped by season and station.

Fall

All BC stations were fully supporting of the beneficial use for the protection of WWH in fall 2019 (Table 5). BC 38.7 had an MSCI score of 18, with the BI metric value in the suboptimal range. This identified the community as more tolerant of organic pollution/disturbance than is found in BIOREF streams of the EDU. BC 35.2 had a slightly lower MSCI score of 16, with suboptimal BI and SDI metric values. This community was similarly tolerant of organic pollution/disturbance, but unlike the station upstream, it was less diverse than BIOREF communities. The decrease in diversity from upstream suggests there was an additional influence limiting the macroinvertebrate community composition. BC 32.6 attained an MSCI score of 18, with a more diverse community than upstream. However, it had the highest BI metric value observed among all BC stations in fall. This suggests the station's community was potentially more influenced by organic pollution/disturbance than other BC communities. BC 27.6 achieved an MSCI score of 20, with all individual metric values reaching the optimal scoring range. BC 23.27 had an MSCI score of 18, with only the BI metric value in the suboptimal range. Overall, individual metric values suggested organic pollution/disturbance was a potential influence at all stations except BC 27.6. However, that influence was not great enough to substantially alter the stream's ability to support its beneficial use designation.

Spring

Three of the five BC stations attained fully supporting status, and two were in the partially supporting category in spring 2021 (Table 6). BC 38.7, the most upstream station, had a fully supporting MSCI score of 16. However, the TR and SDI metric values were in the suboptimal range, which indicated a community that was smaller and less diverse than BIOREF communities. BC 35.2 had a partially supporting MSCI score of 12, which was the lowest among BC stations. All four biological metric values were in the suboptimal range, which indicated a community with substantially fewer taxa, fewer sensitive taxa, more taxa tolerant of organic pollution/disturbance, and a less diverse community than BIOREF streams. BC 32.6 was also partially supporting, with an MSCI score of 14. The TR, EPTT, and SDI metric values describe a community that was smaller, less sensitive, and less diverse than BIOREF streams. Unlike the station immediately upstream, the BI metric value at BC 32.6 was in the optimal BIOREF scoring range, suggesting that organic pollution/disturbance was not the obvious contributor to the suboptimal condition. BC 27.6 had a fully supporting MSCI score of 18. The TR metric value was in the suboptimal range, indicating the community was smaller than BIOREF streams. BC 23.27 attained a fully supporting MSCI score of 20, with all metric values in the optimal range, suggesting that the community was similar to those found in BIOREF streams.

Table 5
 Bryant Creek, Douglas County, Fall 2019 – Individual Metric Value and Score,
 Macroinvertebrate Stream Condition Index Score (MSCI), and Support Category by Station.
 Biological Reference Streams (BIOREF) Criteria Scoring Table (bottom in gray)
 used to calculate metric scores

Station Number	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
BC 38.7 (Hwy. U)	19054	86 ₍₅₎	28 ₍₅₎	5.1 ₍₃₎	3.29 ₍₅₎	18	F
BC 35.2 (CR 114)	19053	85 ₍₅₎	27 ₍₅₎	5.1 ₍₃₎	2.96 ₍₃₎	16	F
BC 32.6 (US 76)	19052	93 ₍₅₎	28 ₍₅₎	6.0 ₍₃₎	3.33 ₍₅₎	18	F
BC 27.6 (Vera Cruz CA)	19051	84 ₍₅₎	30 ₍₅₎	4.7 ₍₅₎	3.34 ₍₅₎	20	F
BC 23.27 (Rippee CA)	19050	101 ₍₅₎	31 ₍₅₎	5.0 ₍₃₎	3.69 ₍₅₎	18	F
Metric Score=5	↔	>79	>25	<5.0	>3.17	20-16	Full
Metric Score=3	↔	79-39	25-13	5.0-7.5	3.17-1.59	14-10	Partial
Metric Score=1	↔	<39	<13	>7.5	<1.59	8-4	Non

BIOREF Scoring Table (bottom) developed from BIOREF streams ($n=11$); TR=Taxa Richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index; (#subscript)=individual metric score; **Bold**=less than optimum value and score; F = fully supporting of the WWH designated use; CR = county road; US = Upstream; CA = Conservation Area or Access; Hwy = state highway.

Table 6
 Bryant Creek, Douglas County, Spring 2021 – Individual Metric Value and Score,
 Macroinvertebrate Stream Condition Index Score (MSCI), and Support Category by Station.
 Biological Reference Stream (BIOREF) Criteria Scoring Table (bottom in gray)
 used to calculate metric scores)

Station Number	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
BC 38.7 (Hwy U)	21026	85 ₍₃₎	37 ₍₅₎	4.5 ₍₅₎	3.18 ₍₃₎	16	F
BC 35.2 (CR 114)	21025	68 ₍₃₎	31 ₍₃₎	4.8 ₍₃₎	2.70 ₍₃₎	12	P
BC 32.6 (US 76)	21024	83 ₍₃₎	29 ₍₃₎	4.5 ₍₅₎	3.11 ₍₃₎	14	P
BC 27.6 (Vera Cruz CA)	21027	80 ₍₃₎	35 ₍₅₎	4.5 ₍₅₎	3.41 ₍₅₎	18	F
BC 23.27 (Rippee CA)	21091	99 ₍₅₎	38 ₍₅₎	4.5 ₍₅₎	3.65 ₍₅₎	20	F
Metric Score=5	↔	>95	>31	<4.7	>3.26	20-16	Full
Metric Score=3	↔	95-47	31-15	4.7-7.3	3.26-1.63	14-10	Partial
Metric Score=1	↔	<47	<15	>7.3	<1.63	8-4	Non

BIOREF Scoring Table (bottom) developed from BIOREF streams ($n=11$); TR=Taxa Richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index; (#subscript)=individual metric score; **Bold**=less than optimum value and score; F = fully supporting of the WWH designated use; P = partially supporting of the WWH designated use; CR = county road; US = Upstream; CA = Conservation Area or Access; Hwy = state highway.

Metric Values – Notable Stations

Two BC stations stood out with respect to individual metric values (Tables 5 and 6). In fall, while other stations had no more than one individual metric value in the suboptimal scoring range, BC 35.2 had two suboptimal metrics. The BI and SDI metric values may suggest that organic pollution/disturbance is a contributor to a less diverse and evenly distributed community. The BI metric value was only 0.1 into the suboptimal range and not the highest among stations in fall; however, the BI metric value was also suboptimal in spring only at this station. Station 35.2 also had suboptimal TR, EPTT, and SDI metric values in the spring, suggesting that the community here was consistently more affected by some factor, such as organic pollution or disturbance, compared to the remaining stations.

Conditions at the upstream station (BC 38.7) were not an obvious influence on BC 35.2 in either season, as its metric values were consistently as good or better than those of BC 35.2. This points to a possible contributor immediately upstream or within BC 35.2. Two tributaries with relatively large watersheds enter BC within the area of BC 35.2 (Figure 2). Dry Fork enters BC upstream of the study reach, and the Bill Macks Creek confluence lies within the station. Algae was abundant at the confluence with Bill Macks Creek, which may indicate nutrient enrichment. Dry Fork enters BC immediately upstream of the station and was considered as a potential source of nutrients due to the Norwood, Missouri, Wastewater Treatment Facility (Permit #MO-0103365), which discharges to Dry Fork. The WWTF outfall, however, is approximately 10

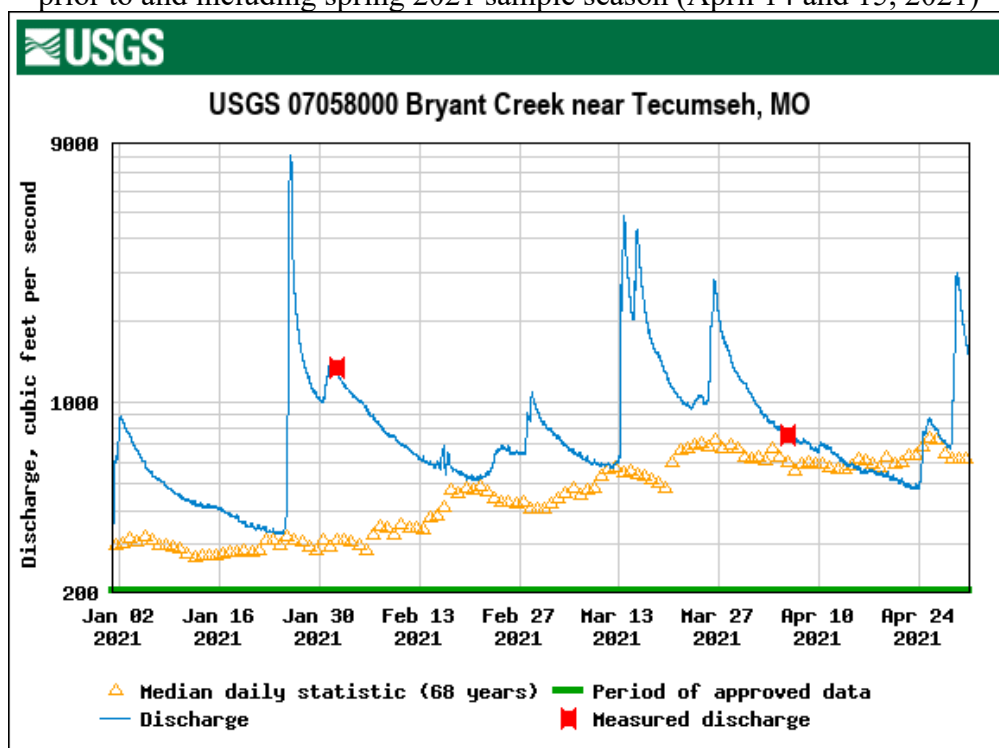
miles upstream of its confluence with BC (Appendix E), and the facility's actual flow is listed as 35,000 gallons/day (approximately 0.05 cfs). The facility's distance upstream of BC and its low actual flow suggest it is likely not a major source of organic pollution under normal conditions. We did not explore upstream of the station, but there was no obvious indicator, such as excessive algae growth, observed at the upstream border of the station.

The second station with notable individual metric values was BC 32.6, downstream from the J and R Sand and Gravel operation. In fall, this station had a fully supporting MSCI score, but it had a suboptimal BI metric value that was much higher than all other stations in the study reach. This describes a community that was not only more tolerant of organic pollution or disturbance than those found in BIOREF streams, but also more tolerant than all remaining stations in the study area. All other metric values were well within their optimal scoring ranges and among the higher values in BC. In the spring, however, BC 32.6 had a partially supporting MSCI score, with three of the four metric values in the suboptimal range. Interestingly, BI was the only metric value to reach the optimal scoring range, and it was similar to BI values at all stations with fully supporting MSCI scores. The taxonomically reduced, less sensitive, and less diverse macroinvertebrate community with an optimal BI metric value suggests that the community either recovered slightly from a possible organic pollution/disturbance influence that potentially affected the station immediately upstream (BC 35.2), or it was affected by a different stressor in spring. Poor Channel Flow Status was notable during the stream habitat assessment due to a braided stream with at least four small channels (Table 4; Appendix F). The braided channel may not have provided the stable environment needed to promote colonization by a larger, more sensitive, and diverse macroinvertebrate assemblage, especially during spring when scouring flows tend to occur.

The property owner of BC 32.6 confirmed that an unusually high flood event occurred not long before our mid-April sampling visit. Based on USGS gage #07058000 at BC near Tecumseh, Missouri, a total of three major discharge events occurred prior to spring sampling (Figure 4). On January 25, 2021, BC discharge increased from its roughly median flow of 300 cfs to over 8000 cfs. In March 2021, there were three rain events in the Bryant Creek watershed that resulted in flows of approximately 3000 to 5000 cfs. By comparison, the median was near 600 cfs. Debris was observed well above the pool level on the left bank in spring.

It is likely that these high flow events affected the spring Bryant Creek biological metric values. Smith et al. (2019) observed that flood events can negatively affect macroinvertebrate taxa richness, EPT taxa, and diversity. Four of the five stations had at least one of these metric values in the suboptimal range in spring. The TR metric value was less than optimal at four of the five stations, excluding the most downstream station. The EPTT was suboptimal at two stations (BC 35.2 and BC 32.6), and the SDI was suboptimal at the three upstream stations. The partially supporting MSCI scores at BC 35.2 and BC 32.6 in spring are likely due at least partly to these flood events.

Figure 4: Discharge in Bryant Creek near Tecumseh, MO from January 1 to April 30, 2021 prior to and including spring 2021 sample season (April 14 and 15, 2021)



(Courtesy USGS – NWIS, Legacy Real-time page)

[USGS Current Conditions for USGS 07058000 Bryant Creek near Tecumseh, MO](#)

3.2.2 General Water Quality

All physicochemical water quality measurements were within acceptable WQS limits (MoDNR 2018d). Water quality results are presented for each season, and any observed trends were noted. Several constituents were higher than EPA suggested guidelines (EPA 2000) in each season. The EPA *Aggregate Nutrient Ecoregion XI, level III ecoregion 39* criteria used for comparison were: 0.239 mg/L nitrate+nitrite as N, 1.425 NTU turbidity, 0.379 mg/L total nitrogen, and 0.006625 mg/L total phosphorus. Results are grouped by season and station.

Fall

All BC physicochemical water quality constituents were within acceptable WQS limits (MoDNR 2018d) in fall 2019 (Table 7). Dissolved oxygen ranged from 6.75 mg/L to 11.57 mg/L, with BC 32.6 and BC 23.27 having lower DO concentrations among stations. Both of these stations were sampled in the morning, which could account for the lower concentrations. Specific conductance ranged between 401 and 423 $\mu\text{S}/\text{cm}$. Turbidity was below detectable levels at BC 35.2 and BC 27.6 but ranged from 1.4 to 3.0 NTU at the remaining stations. Turbidity exceeded EPA guidance at BC 32.6 and BC 23.27. Ammonia was present in detectable concentrations only at BC 38.7 in the fall, but it was well below the chronic WQS concentration (MoDNR 2018d).

Nutrients (total nitrogen, nitrate+nitrite as N, and total phosphorus) were observed in relatively low concentrations, generally increasing from upstream to downstream in fall (Table 7). Total nitrogen ranged from 0.40 to 0.62 mg/L, with downstream stations having the slightly higher concentrations. Nitrate+nitrite as N ranged from 0.37 to 0.64 mg/L among stations, again with higher values downstream. Total phosphorus concentrations were similar among the upstream three stations, ranging between 0.0060 to 0.0080 mg/L, but the downstream two stations had higher concentrations ranging from 0.011 to 0.014 mg/L. Total nitrogen exceeded EPA suggested guidelines at all stations, and total phosphorus exceeded the guidelines at all stations except BC 32.6 (0.0060 mg/L).

Table 7
 Physicochemical Water Constituents for Bryant Creek (BC) Stations, Fall 2019

Station/Date Parameter	BC 38.7 Hwy U	BC 35.2 CR 114	BC 32.6 US 76	BC 27.6 Vera Cruz CA	BC 23.27 Rippee CA
Sample Number	193600	193599	193598	193597	193596
pH (Standard Units)	8.2	7.9	7.9	8.1	8.1
Temperature (°C)	23.9	25.1	21.7	22.8	25.1
Sp. Conductance (µS/cm)	401	402	408	423	422
Dissolved O ₂	9.19	11.57	6.75	9.54	7.62
Discharge (cfs)	0.65	4.98	10.42	46.71	60.12
NFR	<5 ND	<5 ND	<5 ND	<5 ND	5.00
Turbidity (NTUs)	1.4	<1	1.8	<1	3.0
Total Nitrogen	0.40	0.48	0.40	0.62	0.62
Nitrate+Nitrite as N	0.39	0.49	0.37	0.64	0.50
Ammonia-N	0.13	<0.02 _{ND}	<0.02 _{ND}	<0.02 _{ND}	<0.02 _{ND}
Sulfate	4.41 ₀₅	5.63	3.65 ₀₅	4.36 ₀₅	4.67 ₀₅
Chloride	5.28	4.49 ₀₅	4.03 ₀₅	3.74 ₀₅	4.08 ₀₅
Total Phosphorus	0.0068	0.0080	0.0060	0.014	0.011
Calcium	46.9	45.1	45.2	47.7	47.8
Magnesium	23.9	25.1	24.9	26.6	27.5
Hardness	216	216	215	229	233

Units = mg/L unless otherwise labeled; CR = county road; US = Upstream; Hwy = state highway; Italics = exceeding EPA (2000) suggested guidelines: NO₃+NO₂-N >0.239 mg/L; TN >0.289 mg/L; TP >0.006625 mg/L; Turbidity >1.425 NTU. Subscript qualifiers: 05 = estimated value, detected below the Practical Quantitation Limit (PQL); ND = non-detect.

Spring

All BC physicochemical water quality constituents were within acceptable WQS limits (MoDNR 2018d) in spring 2021 (Table 8). Dissolved oxygen ranged from 10.09 to 11.59 mg/L, with BC 32.6 having the highest DO reading among stations. Unlike fall, dissolved oxygen concentrations were similar among stations, with little variation attributable to diel fluctuations. Specific conductance was also similar among stations, ranging from 350 to 364 µS/cm. Turbidity ranged from 0.69 to 1.36 NTUs. Ammonia was not detected at any BC station in spring.

Nutrients were observed in relatively low concentrations and decreased slightly from upstream to downstream in spring (Table 8). Total nitrogen ranged from 0.27 to 0.64, and nitrate+nitrite as N ranged from 0.29 to 0.64 mg/L. Total phosphorus ranged from 0.014 to 0.018 mg/L, decreasing very little from upstream to downstream. Nitrate+nitrite-N and total phosphorus were higher than EPA suggested guidelines (EPA 2000) at all stations, and total nitrogen exceeded guidelines at all but BC 23.27.

Table 8
 Physicochemical Water Constituents in Bryant Creek (BC) Stations, Spring 2021

Station/Date Parameter	BC 38.7 Hwy U	BC 35.2 CR 114	BC 32.6 US 76	BC 27.6 Vera Cruz CA	BC 23.27 Rippee CA
Sample Number	21000393	21000392	21000391	21000390	21000389
pH (Standard Units)	8.34	7.62	8.14	8.25	8.60
Temperature (°C)	16.3	13.5	12.6	12.0	15.6
Sp. Conductance (µS/cm)	362	354	350	364	387
Dissolved O ₂	11.03	10.09	11.59	11.04	11.45
Discharge (cfs)	34.4	71.2	88.5	142	200
NFR	<5 _{ND}	<5 _{ND}	<5 _{ND}	<5 _{ND}	<5 _{ND}
Turbidity (NTUs)	1.22	1.00	1.36	1.06	0.69
Total Nitrogen	<i>0.64</i>	<i>0.63</i>	<i>0.56</i>	<i>0.52</i>	<i>0.27</i>
Nitrate+Nitrite as N	<i>0.594</i>	<i>0.637</i>	<i>0.562</i>	<i>0.541</i>	<i>0.291</i>
Ammonia-N	<0.02 _{ND}	<0.02 _{ND}	<0.02 _{ND}	<0.02 _{ND}	<0.02 _{ND}
Sulfate	6.11	6.78	<3.5 _{ND}	6.56	6.93 ₁₁
Chloride	3.95 ₀₅	3.48 ₀₅	3.20 ₀₅	3.04 ₀₅	2.69 ₀₅
Total Phosphorus	<i>0.018</i>	<i>0.018</i>	<i>0.015</i>	<i>0.016</i>	<i>0.014</i>
Calcium	44.3	40.9	41.0	43.6	44.4
Magnesium	21.8	21.6	21.5	23.6	25.2
Hardness	201	191	191	206	215

Units = mg/L unless otherwise labeled; CR = county road; US = Upstream; Hwy = state highway; Italics = exceeding EPA (2000) suggested guidelines: NO₃+NO₂-N >0.239 mg/L; TN >0.289 mg/L; TP >0.006625 mg/L; Turbidity >1.425 NTU. Subscript qualifiers: 05 = estimated value, result between Method Detection Limit (MDL) and Practical Quantitation Limit (PQL); ND = non-detect; 11 = matrix interference.

Nutrients – Seasonal Trends

Upstream to downstream trends in nutrient concentrations were different between seasons. Concentrations were low and changed very little in each season. However, in fall, nutrients followed a generally increasing trend from upstream to downstream, suggesting sources for nutrients were downstream within the study area. In spring, the opposite trend was observed. Nutrients followed a decreasing trend from upstream to downstream, implying sources were located upstream of or within the upper study area. It appears the watershed upstream of or within the study area contributes slightly more nutrients with greater discharge, perhaps due to runoff during spring rains. As mentioned earlier, land use upstream consists of more grassland and grazing, which may be a source for the slightly higher nutrient concentrations during the

spring. These concentrations did not appear to be obvious contributors affecting the biological support status of each station.

Although nutrient concentrations exceeded EPA's recommended guidelines (EPA 2000) during both seasons, they did not appear to affect MSCI scores at any BC station. However, the concentration of nutrients in these grab samples does not discount the potential for fluctuations due to periodic rain events and increased runoff to BC tributaries. Point sources and land use may contribute nutrients under suitable conditions (Appendix E).

3.3 Data Logger Deployment – Temperature, Specific Conductance, and Turbidity

Data loggers (sondes) were deployed at all BC stations on October 9, 2019, and retrieved on October 23, 2019. During the deployment period, over 2000 temperature, specific conductance, and turbidity measurements were recorded at each BC station. On October 11, 2019, three days into deployment, a major rain event (2.20 inches; NWS 2019) occurred that increased flow from approximately 250 cfs to over 4000 cfs at the USGS gage at Tecumseh, MO (Figure 7). This event moved all sondes from their original positions, but they remained submerged after BC returned to pre-flood conditions. Three sondes (BC 38.7, BC 35.2, and BC 32.6) were recovered in relatively good condition, but the wiper was missing from the one sonde (BC 32.6). One of the remaining sondes (BC 27.6) was found buried under approximately two feet of sand and gravel, and the wiper was bound by gravel on the sonde at the most downstream station (BC 23.27). Despite these challenges, temperature and specific conductance data stabilized after the flood. Turbidity readings, however, were erratic after the flood at BC 27.6 and BC 23.27. For these reasons, temperature and specific conductance data are included for all stations, but turbidity data are presented only for the three sondes whose readings could be considered relatively reliable (BC 38.7, BC 35.2, and BC 32.6).

3.3.1 Data Logger: Temperature

The mean of daily temperatures described conditions by using all measurements for each day (Figure 5; Appendix A). Overall mean daily temperatures ranged from 14.6 to 16.4 °C in the BC study area. The lowest overall mean daily temperature (14.6 °C) was observed at BC 38.7, which is the most upstream station and close to a designated cold-water section of BC (Figure 2). Overall, temperature was highest (16.4 °C) at the next station downstream and decreased at each proceeding station to the end of the study area (15.6 °C). The greatest mean daily temperature changes occurred at most BC stations due to the October 11, 2019, rain event (Figure 5; Figure 7; Appendix A). Mean daily temperatures prior to the rain event were in the 17 to 18 °C range. After the rain, temperatures dropped to the 12 to 14 °C range. The lowest mean daily temperatures were observed at all stations on the final day of deployment. Water temperature did not return to pre-rain event levels for the remainder of the deployment period (Figure 5; Appendix A), likely due to cooler air temperatures in the region during this time (National Weather Service).

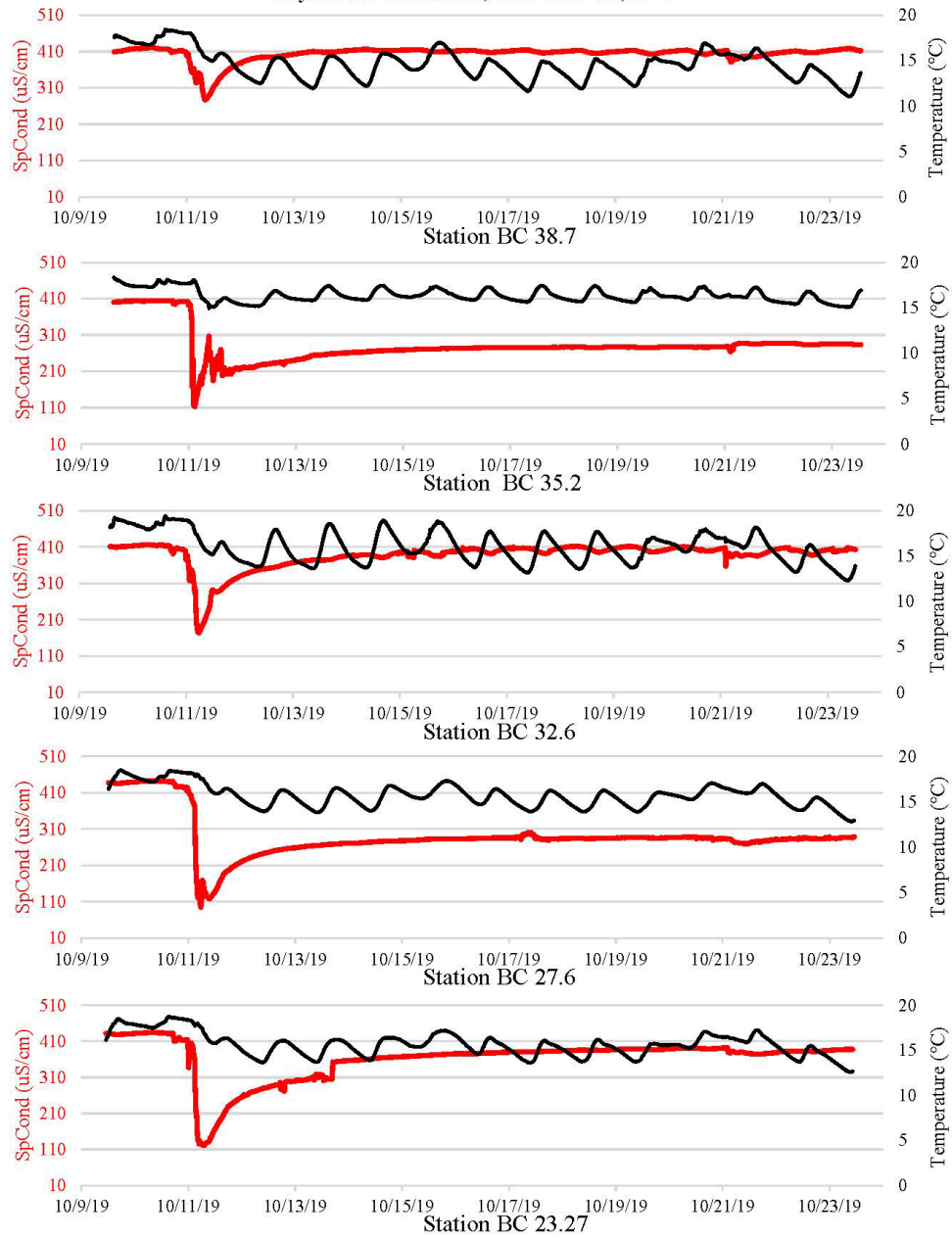
3.3.2 Data Logger: Specific Conductance

Specific conductance (SpC) is defined as the electrical conductance of 1 cm³ of a solution at 25°C and can be used as an indirect measure of the collective concentration of dissolved ions in solution (Hem 1982; USGS 2019). Conductance can change in response to increased stream discharge or the presence of an added pollutant (EPA 2022). Heavy rainfall can lower the specific conductance of stream water as it dilutes the concentration of dissolved ions. This response is expected when there is little additional input of soluble compounds in stormwater runoff.

The mean daily SpC is an indicator of conditions using all measurements taken during each day and through deployment (Appendix A). The overall mean daily SpC ranged from 286 to 404 µS/cm. Means at BC 35.2 and BC 27.6 were approximately 100 µS/cm lower than the three surrounding stations, perhaps due to increased flow from Dry Fork, Bill Macks Creek, and Hunter Creek, or probe interference/damage resulting from the flood. When excluding those exceptions, the overall mean range was from 364 to 404 µS/cm, with SpC decreasing from upstream to downstream. Based on fall *in situ* sampling (Table 7) and data sonde readings before the rain event, the BC SpC range during base flow is from 370 to slightly over 400 µS/cm. The largest change was in response to the storm, in which the mean daily SpC decreased between 75 to 213 µS/cm among stations. The magnitude of these short-term changes increased from upstream to downstream due to additional flow and little apparent additional ionic input.

The rate at which SpC returned to pre-rain event levels shows how long storm water can affect BC water quality (Appendix A). The mean daily SpC at BC 38.7 returned to pre-rain event levels within 2 days, but at BC 35.2 it did not return to pre-event levels during deployment. The mean daily SpC at BC 32.6 returned to pre-event levels at approximately 8 days after the major rain event. The mean daily SpC at BC 27.6 also did not return to pre-event levels during deployment, but this was very likely due to the sonde being buried deep in the substrate and recording hyporheic SpC. The mean daily SpC at BC 23.27, the farthest downstream station, did not return to pre-rain levels (405 µS/cm) during deployment, but it approached pre-event conditions (391 µS/cm) within 9 days. The rate of return slowed from upstream to downstream, likely due to added flow and dilution from major tributaries such as Dry Fork, Bill Macks Creek, Hunter Creek, and Rippee Creek. These tributaries were substantial contributors to flow during both biological assessment sample seasons (Tables 7 and 8). Trends observed during data logger deployment indicate that the 2.2-inch rain affected SpC levels from 2 to at least 9 days in the BC study area.

Figure 5: Data Logger - Temperature and Specific Conductance in Bryant Creek Stations, October 9-23, 2019



Graph by R. Mott

3.3.3 Data Logger: Turbidity

Turbidity data were collected continuously throughout the 14-day deployment period at all stations (Figure 6; Appendix A). However, data from two stations are not included in this discussion. All sondes were moved from their original positions during the October 11, 2019 rains (Figure 7). This event appears to have affected readings at stations BC 27.6 and BC 23.27 more than the others, as evidenced by numerous erratic readings after the storm. The BC 27.6 sonde was found buried under two feet of substrate, and the wiper of the BC 23.27 sonde was bound by debris upon retrieval. Because both situations are likely to have affected the turbidity readings, turbidity data from BC 27.6 (Vera Cruz CA) and BC 23.27 (Rippee CA) are not included in this discussion. Data are presented for BC 38.7, BC 35.2, and BC 32.6. It is common for anomalous or erroneous readings to occur during long-term data logger deployment, which can be caused by environmental factors obstructing optical probe lenses. It is necessary to scrutinize the data set and remove erroneous data points prior to analysis (Alferes et al. 2013; Yousif et al. 2022). A small number of data points that were clearly outliers were removed from the dataset before statistical tests were conducted.

Turbidity fluctuated daily within all BC stations during deployment (Appendix A). All stations experienced their greatest changes as a result of the October 11, 2019, rain event (Figure 6; Figure 7; Appendix A). Turbidity ranged from 0 to 186 FNU at BC 38.7, which was the smallest increase among stations. The greatest increase in turbidity was from 0 to 1098 FNU at BC 35.2. The range of extreme values on the day of the rain event identify areas where constituents in runoff from the watershed may be contributed to the stream, and/or disturbance of settled organic or inorganic particulates may be suspended within the stream.

Statistical analyses were conducted for turbidity among BC 38.7, BC 35.2, and BC 32.6 (Appendix B). One-way ANOVA calculations showed that turbidity levels were significantly different ($P < 0.001$) among stations (Appendix B). Holm-Sidak All Pairwise Multiple Comparison Procedures indicated that turbidity was significantly greater at BC 35.2 than at the surrounding stations. Turbidity was not significantly different ($P > 0.05$) between BC 38.7 and BC 32.6. Because measurements were not normally distributed, Kruskal-Wallis ANOVA on Ranks and Dunn's All Pairwise Multiple Comparison Procedures were used to determine if there were differences among BC stations, and if so, where they were found. Results were similar to the parametric test, in that there was a significant difference ($P < 0.001$) among stations. However, the median at BC 35.2 was significantly lower than the surrounding stations. The difference between the significantly high mean (ANOVA) and significantly low median (ANOVA on Ranks, accounting for extreme values) described the great short-term effect the storm had on turbidity at BC 35.2.

Mean daily turbidity data collected during deployment are presented in Appendix A. The mean daily turbidity is based on readings collected every 10 minutes, which amounted to approximately 140 measurements per day and over 2000 measurements per station. The mean daily turbidity per day was greatest during the October 11, 2019, storm at all stations. The mean

daily turbidity during the storm was 40.5 FNU at BC 38.7 and 44.3 FNU at 32.6. BC 35.2 saw a mean daily turbidity of 144 FNU, which was over 3-times higher than the remaining stations. The overall mean daily turbidity for the entire deployment period was 4.4 FNU at BC 38.7, 10.2 FNU at BC 35.2, and 4.7 FNU at BC 32.6. All overall means were influenced by the discharge pulse that occurred during the rain, especially at BC 35.2. Mean daily turbidity results suggested the presence of a substantial short-term source for inorganic or organic constituents in the watershed, immediately upstream, or within BC 35.2 that is not as prevalent at the two bracketing stations.

Mean daily turbidity values also show the duration of elevated turbidity levels after the rain event (Appendix A). Although the highest turbidity values only lasted 1 day at all stations, the mean daily turbidity returned to pre-event levels at different rates. Turbidity at BC 38.7 returned to pre-event levels within 3 days of the rain event. BC 35.2 reached pre-event turbidity levels within 4 days and maintained the low values for the remainder of deployment. Turbidity at BC 32.6 did not return to pre-event levels until 6 days after the rain event. The duration of elevated values may indicate additional sources of turbidity within or immediately upstream of BC 32.6 (Appendix F).

Turbidity is a relative measure of water clarity that is influenced by suspended organic and inorganic material (EPA 2012). Suspended inorganic components such as clay, silt, and fine sand can be resuspended or added to the stream through soil and bank erosion and deposited as water velocity decreases. Both suspended and deposited particles can have wide ranging effects on aquatic biota (Jones et al. 2011). These effects include increased water temperature, clogging the gills of aquatic organisms, and filling interstitial spaces in the substrate used for habitat by benthic life. There was a sharp increase in discharge and turbidity at all BC stations due to the rain event that occurred on October 11, 2019, and elevated turbidity values lasted from 3 to 6 days. Turbidity is not likely to have affected macroinvertebrate communities as suspended material during short-lived high flow periods, but the settling of suspended materials as fine sediment can directly influence benthic communities.

3.3.4 Data Logger: Quality Control

The quality assurance process for sonde deployment data required *in situ* quality control (QC) checks to determine if sondes were reading accurately during the deployment period. Quality control included *in situ* side-by-side comparisons between sondes and the YSI handheld meter readings (Tables 9 and 10). The percent difference between each sonde and the handheld meter was then compared to acceptable limits defined in the FY 2020 QAPP (MoDNR 2019b). Constituents measured and recorded by the sondes included temperature, specific conductance (SpC), and turbidity.

Temperature and Specific Conductance

All temperature and SpC comparisons were within the defined QC limits at deployment, but two sondes were outside defined QC limits upon retrieval (Table 9). As mentioned earlier, the sonde at BC 27.6 was found buried under 2 feet of substrate, so side-by-side comparisons could not be made for temperature or SpC. The SpC sonde measurement at BC 35.2 (284 $\mu\text{S}/\text{cm}$) was outside the acceptable ± 10 percent range (24 percent RPD) when it was compared with the handheld meter reading (372.4 $\mu\text{S}/\text{cm}$) upon retrieval. The handheld meter reading at BC 35.2 was relatively similar to other handheld and sonde measurements in BC on the day of retrieval. This consistency suggests that the BC 35.2 handheld reading was accurate, but the sonde reading was not. Interestingly, during post deployment QC checks of sondes in the laboratory using certified standards, the BC 35.2 measurements were well within acceptable limits.

The SpC measurements for the sonde at BC 35.2 (284 $\mu\text{S}/\text{cm}$) and the buried sonde at BC 27.6 (289 $\mu\text{S}/\text{cm}$) were very similar to one another, and both were considerably lower than sonde readings at the remaining stations. It is possible the two SpC probes became similarly damaged or fouled at some point during deployment, potentially as a result of increased flow due to the heavy rain event on October 11, 2019 (Figure 7; Appendix A). SpC data from these two stations should be viewed with skepticism.

Table 9
 Quality Control (QC) Checks at Deployment and Retrieval
 for Temperature and Specific Conductance

Station	Date/Time	Temp HH	Temp DL	± 0.3	SpC HH	SpC DL	$\pm 10\%$	Comment
BC 38.7	10.9.19/1540	17.6	17.58	ok	385.6	409	ok	
	10.23.19/1400	13.9	13.62	ok	379.7	412	ok	
BC 35.2	10.9.19/1440	18.2	18.23	ok	392.8	400	ok	
	10.23.19/1310	16.9	16.91	ok	372.4	284	>10%	SC probe *
BC 32.6	10.9.19/1350	18.2	18.16	ok	377.5	412	ok	
	10.23.19/1230	14.0	13.91	ok	367.3	403	ok	
BC 27.6	10.9.19/1210	16.4	16.42	ok	406.9	437	ok	
	10.23.19/1100	N/A	12.94	--	N/A	289	--	Buried
BC 23.27	10.9.19/1100	16.1	16.15	ok	406.2	431	ok	
	10.23.19/1020	12.6	12.66	ok	384.7	388	ok	

*QC *in situ* = 27% RPD, in lab post deployment = ok; QC Acceptable limits - Temperature ± 0.3 °C; Sp. Conductance ± 10 percent of HH. Abbreviations: HH = Handheld; SpC = Specific Conductance; Temp. = Temperature; DL = Data Logger. Values - Temperature = °C; Specific Conductance = $\mu\text{S}/\text{cm}$; **Bold** = Outside QC Range; N/A = Not available.

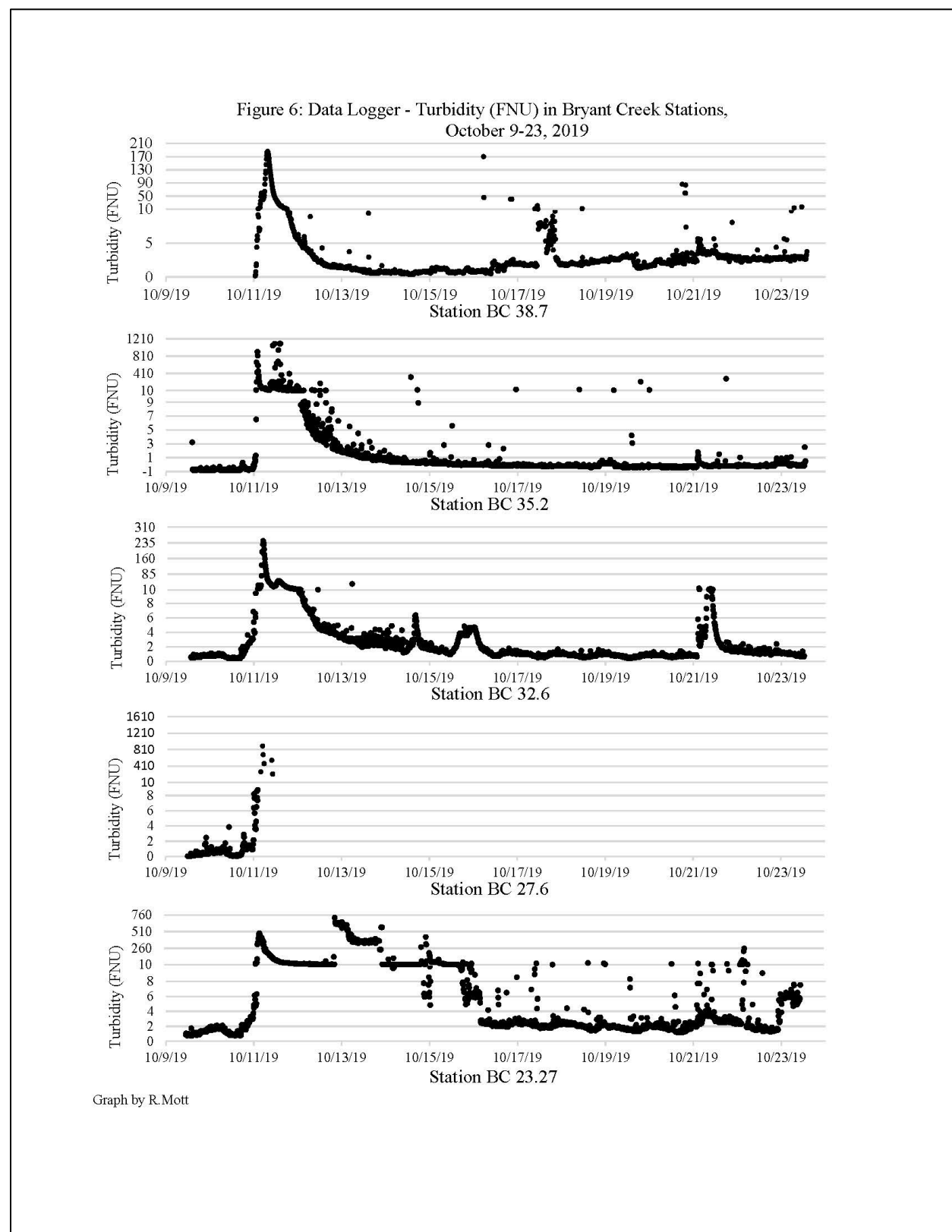
Turbidity

Quality control checks included side-by-side comparisons *in situ* between turbidity sondes and a YSI ProDSS handheld meter at deployment and retrieval (Table 10). Side-by-side measurements were recorded, and percent difference calculated for each comparison. During deployment, three of the five sonde readings were within the acceptable range (± 5 percent), but the two remaining comparisons were slightly outside the range with very low values (<1.0 FNU). At retrieval, all five of the sonde/handheld comparisons were notable. As mentioned, one sonde was buried under 2 feet of sand and gravel upon retrieval, and QC comparisons could not be made. Three of the four remaining sonde readings were outside the acceptable RPD limit. Two (BC 35.2 and BC 32.6) of the three measurements were very low (<1.0 FNU), and one (BC 38.7) was relatively low with possible organic interference. Long-term turbidity measurements of <100 FNU are very susceptible to biofouling and non-biological fouling (YSI 2020). However, there remains an overall level of confidence that the majority of turbidity values correctly measured conditions in BC and fluctuations during a major storm event.

Table 10
 Quality Control (QC) Checks at Deployment and Retrieval for Turbidity

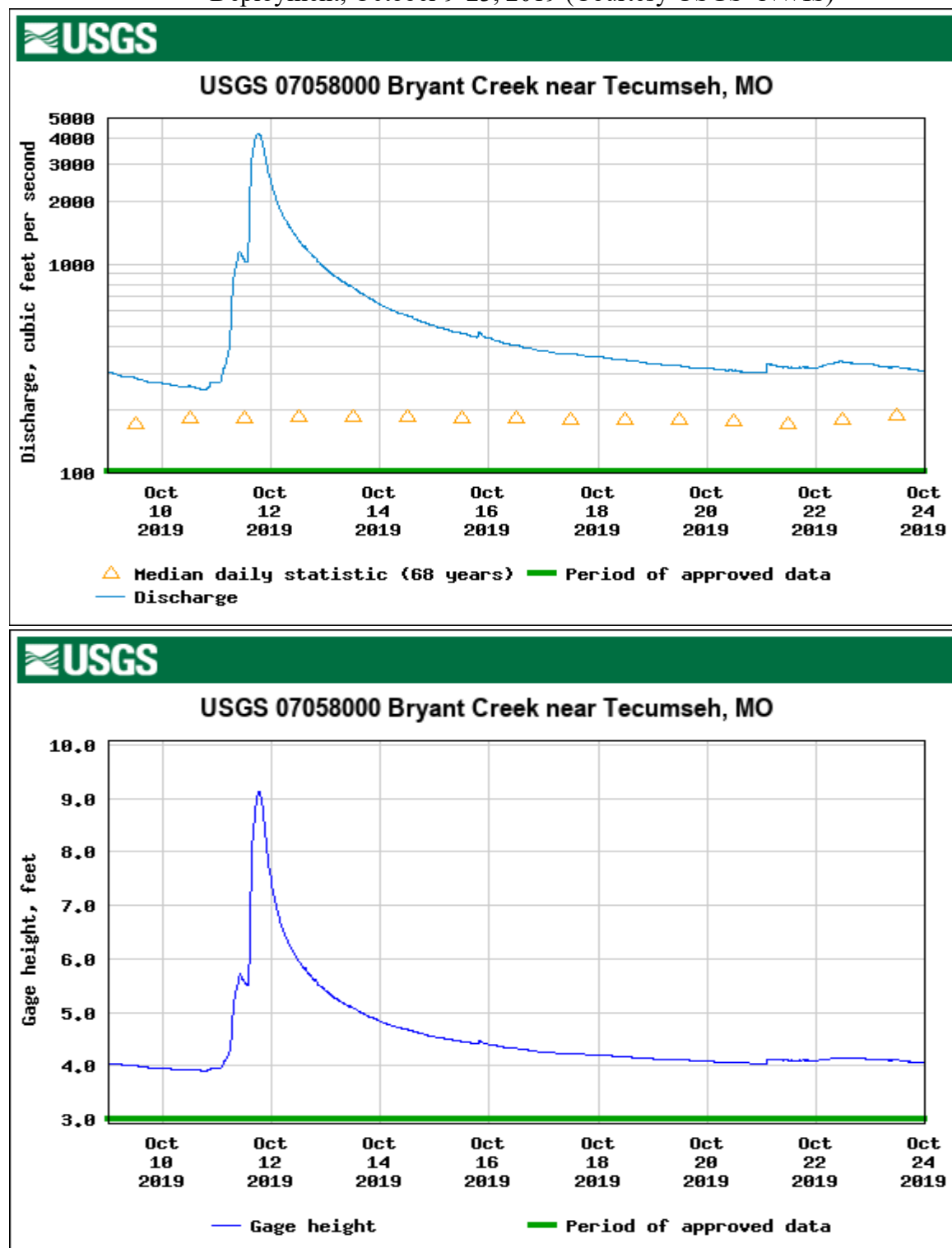
Station	Date/Time	Turb. HH	Turb. DL	$\pm 5\%$	Comment
BC 38.7	10.9.19/1540	0	0	ok	
	10.23.19/1400	0	3.7	>5%	Low values; Possible interference
BC 35.2	10.9.19/1440	0	0	ok	
	10.23.19/1310	0	0.5	>5%	Very low values
BC 32.6	10.9.19/1350	0.15	0.6	>5%	Very low values
	10.23.19/1230	0.39	0.7	>5%	Very low values
BC 27.6	10.9.19/1210	0	0	ok	
	10.23.19/1100	N/A	361.9	--	Buried
BC 23.27	10.9.19/1100	0.29	0.9	>5%	Very low values
	10.23.19/1020	0.47	7.5	>5%	Wiper bound by rocks

N/A=not available; QC Acceptable Limits - Turbidity ± 5 percent of HH; Abbreviations: HH=Handheld; DL=Data Logger/sonde; Turb.=Turbidity; Value - FNU=Formazin Nephelometric Units; **Bold** = Outside QC Range.



Sonde data removed for BC 27.6; Raw data presented here; See Appendix A for corrected turbidity summary values.

Figure 7: Discharge and Gage Height in Bryant Creek (near Tecumseh, MO) during Data Logger Deployment, October 9-23, 2019 (Courtesy USGS- NWIS)



[USGS Current Conditions for USGS 07058000 Bryant Creek near Tecumseh, MO](#)

3.4 Fine Sediment Coverage, Size Class, and Distribution

The coverage of benthic fine sediments can influence aquatic communities by directly affecting biota (e.g. gill erosion) and by eliminating useable habitat. Three benthic fine sediment aspects were examined for the BC study area. Benthic fine sediment coverage was estimated at each station and compared among stations. The dominant size classes (i.e. silt or sand) of fine sediment were identified within each station, and the prevalence of silt or sand was compared among stations. The distribution of fine sediment size classes was also identified for each station. Combined, these three aspects describe the prevalence and distribution of silt and sand coverage at similar points in each station. Differences in the coverage of silt or sand among stations may identify influences on the aquatic community and their possible sources.

Fine Sediment Coverage per Station

Step one was to estimate the areal coverage of benthic fine sediment at all BC stations. Estimated coverage ranged from 2.5 to 97.5 percent at BC 32.6 (Table 11; Figure 8). Most estimates among the remaining stations were between 0 and 30 percent coverage, with only a few above that range. One-Way ANOVA and Holm-Sidak All-Pairwise Multiple Comparison Procedures calculated a significant difference ($P < 0.05$) in the coverage among stations, and coverage was significantly greater at BC 32.6 than at all other stations (Table 11; Appendix C). There were no significant differences among the remaining stations. Due to the very wide range of observations, estimates had unequal variance and were not normally distributed. Kruskal-Wallis ANOVA on Ranks and All Pairwise Multiple Comparison Procedures (Tukey Test) were used to identify differences in fine sediment coverage among stations (Appendix C). Tests on Ranks and Comparisons showed that there was a significant difference among stations, and BC 32.6 had a significantly greater ($P = 0.002$) median coverage than BC 38.7 and BC 23.27, which are the most upstream and downstream stations, respectively. Fine sediment coverage at BC 32.6 was not significantly different from BC 35.2 and BC 27.6, its surrounding stations. However, their means and medians were much less than half of those at BC 32.6. It appears fine sediment coverage was much greater at BC 32.6 than at the four remaining stations in BC.

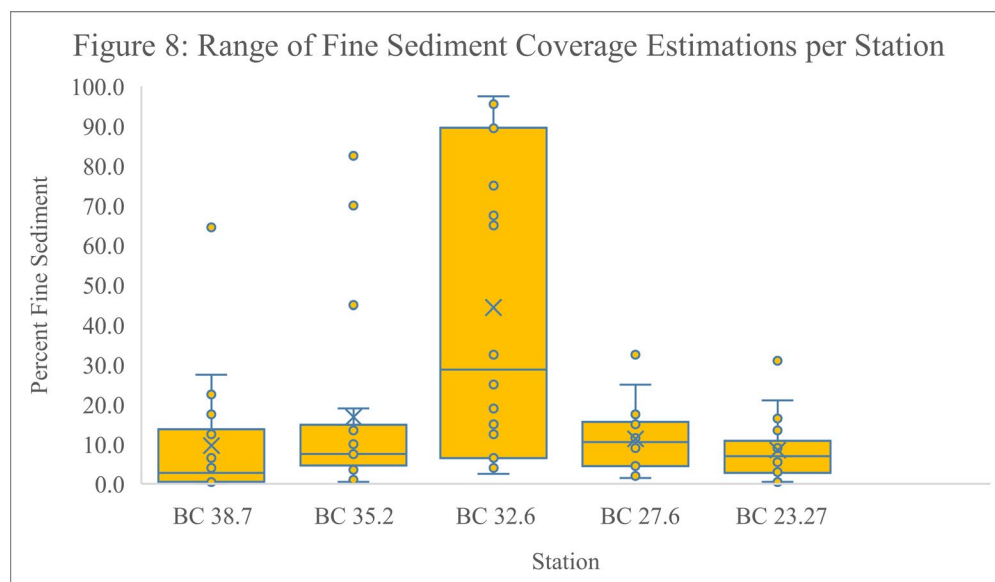
Fine Sediment Size Classes - Silt versus Sand

The second step was to conduct tests for all stations to determine if the fine sediment observed within stations was silt (< 0.625 mm) or sand (0.625 - 2.0 mm) sized substrate (Table 12; Figure 9; Appendix C). Two-way ANOVA and the Holm-Sidak multiple comparisons indicated BC 32.6 had a significantly greater ($P < 0.05$) silt coverage than sand, while BC 38.7 and BC 35.2 had significantly higher percentages of sand coverage compared to silt. Both BC 27.6 and BC 23.27 contained an even mix of silt and sand when fine sediment was observed.

Table 11: Fine Sediment Coverage Estimations per Station

Grid-Transect	BC 38.7	BC 35.2	BC 32.6	BC 27.6	BC 23.27
1-1	0.00	7.50	4.00	32.50	1.00
1-2	1.00	19.00	6.50	15.00	0.50
1-3	0.50	7.50	19.00	12.50	0.50
1-4	0.50	7.50	2.50	9.50	3.00
1-5	0.50	10.00	25.00	25.00	2.00
1-6	1.00	13.50	15.00	17.50	3.00
2-1	64.50	0.50	32.50	10.00	10.00
2-2	0.50	3.50	4.00	19.00	31.00
2-3	22.50	7.50	90.00	2.50	10.00
2-4	1.50	7.50	6.50	11.50	21.00
2-5	1.50	1.00	12.50	5.00	9.00
2-6	27.50	5.00	95.50	2.00	3.00
3-1	6.50	7.50	75.00	4.50	16.50
3-2	5.00	45.00	91.00	11.50	9.50
3-3	6.50	7.50	67.50	9.00	6.50
3-4	4.00	82.50	97.50	4.50	5.50
3-5	17.50	1.00	65.00	1.50	7.50
3-6	12.50	70.00	89.50	11.00	13.50
Mean	9.64 ^b	16.86 ^b	44.36 ^a	11.33 ^b	8.50 ^b
s.d.	15.99	23.88	38.00	8.23	8.00

Also see Figure 8 and Appendix C; Superscripts: Same letter equals not significantly different ($P > 0.05$) among stations using One-way ANOVA and Holm-Sidak, e.g. a = significantly different ($P < 0.05$) from all remaining stations; b = not significantly different ($P > 0.05$); s.d. = standard deviation.

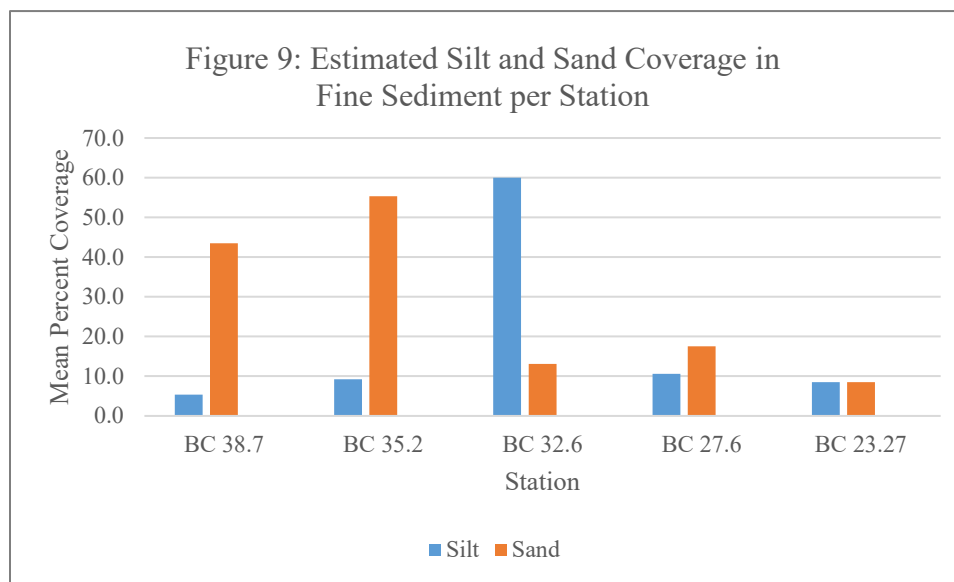


Dominant fine sediment size classes were then compared among BC stations (Table 12; Figure 9; Appendix C). Silt made up 60 percent of the fine sediment observed in BC 32.6, while silt ranged from 5.4 to 10.6 percent at the remaining stations. The percentage of silt at BC 32.6 was significantly greater ($P < 0.05$) than all other stations. There was no significant difference ($P > 0.05$) in the percentage of silt among those remaining stations. Sand made up 55.3 percent of fine sediment observed at BC 35.2, which was significantly different ($P < 0.05$) from the small percentage observed at BC 32.6 (13.1 percent) and BC 23.27 (8.5 percent). The larger percentages of sand at BC 38.7 (43.5 percent) and BC 27.6 (17.5 percent) were not significantly different ($P > 0.05$) from BC 35.2 or the remaining stations.

Table 12: Two-way ANOVA Analysis of Estimated Mean Coverage of Silt and Sand Within and Among Stations (see Appendix C)

Station	Silt	Sand
BC 38.7	5.4 b	43.5 a,b
BC 35.2	9.2 b	55.3 a
BC 32.6	60.0 a	13.1 b
BC 27.6	10.6 b	17.5 a,b
BC 23.27	8.5 b	8.5 b

Bold = significantly higher ($P < 0.05$) within the station; same letter indicates no significant difference ($P > 0.05$) in silt or sand among stations.



Distribution of Silt or Sand

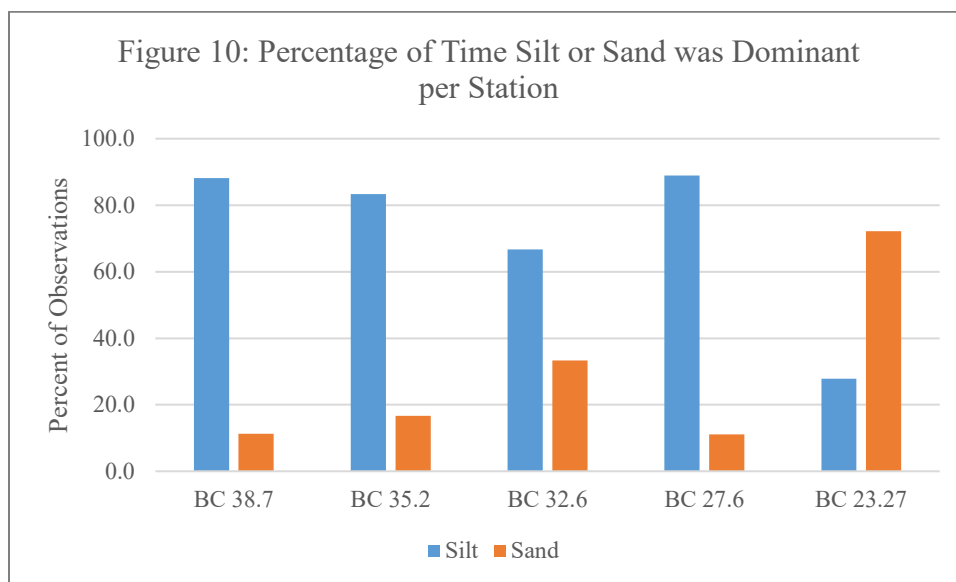
The third step was to determine how silt or sand was distributed in each station by measuring the frequency with which silt or sand was observed as the dominant fine sediment size class (Table 13; Figure 10). Silt was observed more frequently at four of the five BC stations, ranging from 66.7 to 88.9 percent of the time. This suggests silt was more evenly distributed or scattered,

depending on the percent coverage shown in Table 12. Conversely, sand was observed less frequently at those four stations, indicating a patchy distribution. Sand was observed more frequently (72.2 percent) only at BC 23.27, implying it was evenly distributed or scattered depending on the percent coverage shown in Table 12. At BC 23.27, silt was not frequently observed, which suggests it had a patchy distribution.

Table 13: Percentage and Number of Observations Silt or Sand was Dominant per Station

Station	Silt	Sand
BC 38.7*	88.2; n=15	11.8; n=2
BC 35.2	83.3; n=15	16.7; n=3
BC 32.6	66.7; n=12	33.3; n=6
BC 27.6	88.9; n=16	11.1; n=2
BC 23.27	27.8; n=5	72.2; n=13

* For BC 38.7, n=17; all others n=18



Description of Benthic Fine Sediment Distribution per Station

In this section, all three aspects of the fine sediment study are summarized to describe the distribution of silt and sand within each station. The percent coverage of fine sediment per station was estimated, identified as silt or sand, and the distribution was described for each station. The percent fine sediment was first presented in terms of benthic coverage (Table 11; Figure 8). The percentage of silt and sand as part of the fine sediment coverage was then calculated for each station (Table 12; Figure 9). Finally, the frequency with which silt or sand was observed as the dominant fine sediment size class was used to characterize the distribution (Table 13; Figure 10). For example, a high percent coverage of silt that was frequently observed describes a station with substantial silt coverage that was evenly distributed.

Fine sediment prevalence, size class, and distribution is described for each station. BC 38.7 had little coverage of sand-sized material. Silt was observed more frequently than sand, so it appears silt was evenly distributed yet scattered, whereas sand was relatively abundant but patchy. BC 35.2 had a slight coverage of sand. Silt was again observed more frequently than sand, which suggests silt is evenly distributed yet scarce, and sand was relatively abundant and patchy. BC 32.6 had a significant coverage of silt both within and among stations. Silt was present in the majority of observations, which suggests it was abundant and evenly distributed, whereas sand was less abundant and not as evenly distributed. BC 27.6 had a slight coverage of an even mix of silt and sand. However, silt was more frequently observed than sand, suggesting silt was more evenly distributed yet sparse, while sand was sparse and patchy. BC 23.27 had a small amount of silt and sand. Sand was observed much more frequently than silt, suggesting sand was evenly distributed yet sparse, while silt was sparse and patchy.

Importantly, fine sediment was not a major component of the substrate size classes at most BC stations. Silt was scarce and evenly distributed, perhaps as a function of fine sediment settling after rain events discussed in Section 3.3. Silt was abundant and more evenly distributed only at BC 32.6 near US 76, downstream of J and R Sand and Gravel. Sand was more prevalent but patchy at the majority of stations. Sand was scarce but evenly distributed at only BC 23.27, the most downstream station at Rippee CA.

Notable Station

Combining benthic fine sediment data identified a substantially different benthic fine sediment coverage at BC 32.6 (downstream of J and R Sand and Gravel and upstream of US 76) than at the remaining BC stations. Fine sediment was much more prevalent at BC 32.6 than all other stations, and that fine sediment consisted of more silt than all remaining stations. Silt was also observed more often than sand, suggesting it was evenly distributed as part of the substrate.

These points suggest there is some substantial source of silt within or upstream of BC 32.6 that is not prevalent at any other BC station. It was noted during the SHAPP process that there was no wooded riparian corridor on the right bank, yet both banks were stable within the station. However, the right bank immediately upstream of the station had no wooded riparian buffer, the soil was loose, and it appeared to be eroding. The stream at this station was wider than all other stations and was on the downstream side of a sharp bend (Appendix F). A decrease in velocity downstream of the bend allowed for silt to settle widely at this station. J and R Sand and Gravel owns property within and upstream of BC 32.6 and is permitted to wash gravel away from the stream with no discharge to BC. Their wash area is approximately 0.25 miles from the stream, and the team did not observe a discharge to BC. However, the team also did not search for a discharge upstream of BC 32.6 and downstream from BC 35.2. Gravel washing was not an obvious contributor of the silt-sized fine sediment to BC during either sampling event. If instream activity exists upstream of the station, removing instream substrates could increase the gradient, and disturbing the substrate could increase bank erosion and resuspend silt from the substrate to be deposited downstream.

4.0 Conclusions

The project objectives have been addressed. Stream habitat quality was evaluated. Support status for the designated beneficial use has been determined for each BC station using metrics generated from the benthic macroinvertebrate community composition. Physicochemical water quality results were assessed. Temperature, specific conductance, and turbidity conditions in BC stations were recorded using data sondes. The relative coverage and size class of benthic fine sediment were recorded.

- 1) Stream habitat quality at all streams will be comparable to the stream habitat control.
 - The null hypothesis was not rejected.
- 2) Macroinvertebrate Stream Condition Index (**MSCI**) scores will indicate that Bryant Creek stations are fully supporting of the WWH beneficial use, and individual biological metrics will be within the optimum scoring range of wadeable/perennial reference stream biological criteria during the fall and spring seasons.
 - The null hypothesis regarding fully supporting of the WWH beneficial use was not rejected for all stations in fall. The null hypothesis was rejected for BC 35.2 and BC 32.6 in spring as both were partially supporting of the designated use.
 - The null hypothesis regarding individual metric values being within the optimal scoring range of the BIOREF criteria was not rejected for BC 27.6 in fall. The null hypothesis was rejected for the four remaining stations, each having at least one metric (BI) value outside the optimal range. BC 35.2 had the most individual metrics outside the optimal range in fall.
 - The null hypothesis for individual metric values was not rejected for BC 23.27 in spring. The null hypothesis was rejected for the four remaining stations. BC 35.2 had the most individual metrics outside the optimal range, followed by BC 32.6 in spring. Multiple high flow events in the weeks prior to spring sampling may have affected macroinvertebrate scores.
- 3) Physicochemical water quality variables will be within acceptable limits as specified in Missouri's Water Quality Standards (**WQS**; MoDNR 2018d) and not otherwise notable.
 - The null hypothesis regarding water quality constituents being within acceptable WQSs was not rejected for all stations in fall and spring.

- The null hypothesis regarding water quality constituents being otherwise notable was rejected for exceeding EPA recommended guidelines (EPA 2000) for nutrient concentrations (TN, $\text{NO}_3+\text{NO}_2\text{-N}$, TP) at all stations in fall and all but TN at BC 23.27 in spring.
- 4) Data logger water quality constituents will be similar among stations throughout deployment.
- The null hypotheses regarding temperature, specific conductance, and turbidity being similar among stations were rejected.
 - Temperatures were generally similar, being within a few degrees among stations; however, overall temperature was highest at BC 35.2 and decreased at each station downstream during deployment. Temperature decreased substantially at all stations as a result of heavy rains and did not return to pre-event levels due to cool air temperatures during deployment.
 - Specific conductance was generally similar among stations prior to the rain event. SpC then decreased substantially at all stations during the rains, but magnitude and duration of these lower values differed. SpC at two stations (BC 35.2 and BC 27.6) fluctuated substantially and did not return to pre-event levels during deployment. It should be noted, however, that the BC 27.6 sonde was found buried at the end of deployment and was likely recording hyporheic conditions, and the BC 35.2 sonde failed its QC check upon retrieval.
 - Turbidity was low and generally similar among stations prior to the rain event. Afterward, turbidity increased to varying levels and remained elevated for 3 to 6 days. Turbidity was substantially higher at BC 35.2 (downstream of Dry Fork and Bill Macks Creek) than other stations. BC 32.6 turbidity remained elevated for the longest duration. It should be noted that the BC 32.6 sonde was missing its sensor wiper when it was retrieved, which may have affected turbidity readings.
- 5) Benthic fine sediment coverage and size classes will be similar among stations.
- The null hypothesis regarding benthic fine sediment coverage and size classes being similar among stations was rejected.
 - BC 32.6 had significantly greater coverage of fine sediment than all remaining stations. Unlike all other stations, fine sediment was composed of significantly more silt, and it was evenly distributed on the stream bottom. Fine sediment was not prevalent at the four remaining stations. However, fine sediment at three of the four stations was largely made up

of sand with a patchy distribution. Silt and sand were similarly abundant at BC 23.27, but sand was evenly distributed whereas silt was patchy.

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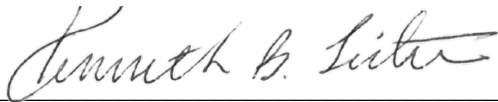
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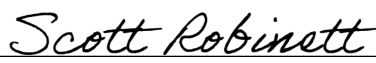
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Appendix A: Data Logger (Sonde) Deployment – Temperature, Specific Conductance, and Turbidity Data for Bryant Creek Stations, October 9-23, 2019

Temperature (°C)					
Station: Bryant Creek 2535 38.7, Douglas Co.			Location: 0.1 mile below Hwy U.		
Survey Period: 15 Days		Start: 10-09-2019		Stop: 10-23-2019	Observations: 2007
Day	Date	Mean Daily Temperature	Minimum Daily Temperature	Maximum Daily Temperature	Change Daily Temperature
*1	10/09/2019	17.40	16.99	17.74	0.75
2	10/10/2019	17.55	16.72	18.43	1.71
3	10/11/2019	15.73	13.74	18.02	4.28
4	10/12/2019	13.88	12.51	15.34	2.83
5	10/13/2019	13.78	11.96	15.48	3.52
6	10/14/2019	14.14	12.19	15.78	3.59
7	10/15/2019	15.32	13.98	16.95	2.97
8	10/16/2019	14.18	12.95	15.43	2.48
9	10/17/2019	13.38	11.64	14.94	3.30
10	10/18/2019	13.59	11.92	15.20	3.28
11	10/19/2019	13.85	12.19	15.31	3.12
12	10/20/2019	15.33	14.01	16.92	2.91
13	10/21/2019	15.52	14.41	16.38	1.97
14	10/22/2019	13.53	12.51	14.56	2.05
*15	10/23/2019	11.95	11.02	13.62	2.60
Mean	15 days *Partial	14.61	13.25	16.01	2.76

Temperature (°C)					
Station: Bryant Creek 2535 35.2, Douglas Co.			Location: 0.1 mile above CR 76-114		
Survey Period: 15 Days		Start: 10-09-2019		Stop: 10-23-2019	Observations: 2009
Day	Date	Mean Daily Temperature	Minimum Daily Temperature	Maximum Daily Temperature	Change Daily Temperature
*1	10/09/2019	17.71	17.38	18.35	0.97
2	10/10/2019	17.63	17.26	18.11	0.85
3	10/11/2019	16.05	14.93	18.05	3.12
4	10/12/2019	15.89	15.18	16.87	1.69
5	10/13/2019	16.40	15.82	17.42	1.60
6	10/14/2019	16.48	15.85	17.45	1.60
7	10/15/2019	16.64	16.16	17.35	1.19
8	10/16/2019	16.37	15.86	17.31	1.45
9	10/17/2019	16.32	15.64	17.43	1.79
10	10/18/2019	16.29	15.68	17.41	1.73
11	10/19/2019	16.25	15.60	17.19	1.59
12	10/20/2019	16.44	15.90	17.37	1.47
13	10/21/2019	16.34	15.65	17.25	1.60
14	10/22/2019	15.84	15.31	16.84	1.53
*15	10/23/2019	15.48	15.09	16.93	1.84
Mean	15 days *Partial	16.41	15.82	17.42	1.60

Comments: Sonde moved downstream by flood.

Temperature (°C)					
Station: Bryant Creek 2535 32.6, Douglas Co.			Location: above Hwy 76		
Survey Period: 15 Days		Start: 10-09-2019		Stop:10-23-2019	Observations: 2009
Day	Date	Mean Daily Temperature	Minimum Daily Temperature	Maximum Daily Temperature	Change Daily Temperature
*1	10/09/2019	18.77	18.16	19.22	1.06
2	10/10/2019	18.62	17.93	19.42	1.49
3	10/11/2019	16.25	14.49	18.95	4.46
4	10/12/2019	15.37	13.83	17.94	4.11
5	10/13/2019	15.66	13.62	18.57	4.95
6	10/14/2019	15.99	13.76	18.93	5.17
7	10/15/2019	16.79	15.28	18.82	3.54
8	10/16/2019	15.65	13.73	17.73	4.00
9	10/17/2019	15.29	13.16	17.76	4.60
10	10/18/2019	15.47	13.57	17.70	4.13
11	10/19/2019	15.46	13.73	17.09	3.36
12	10/20/2019	16.67	15.47	17.96	2.49
13	10/21/2019	16.70	15.42	18.18	2.76
14	10/22/2019	14.66	13.22	16.26	3.04
*15	10/23/2019	13.04	12.31	14.03	1.72
Mean	15 days *Partial	16.03	14.51	17.90	3.39

Comments: Wiper missing

Temperature (°C)					
Station: Bryant Creek 2535 27.6, Douglas Co.			Location: below CR 228		
Survey Period: 15 Days		Start: 10-09-2019		Stop:10-23-2019	Observations: 2011
Day	Date	Mean Daily Temperature	Minimum Daily Temperature	Maximum Daily Temperature	Change Daily Temperature
*1	10/09/2019	17.87	16.42	18.48	2.06
2	10/10/2019	17.81	17.15	18.42	1.27
3	10/11/2019	16.66	15.22	18.17	2.95
4	10/12/2019	15.04	13.96	16.31	2.35
5	10/13/2019	15.13	13.85	16.54	2.69
6	10/14/2019	15.37	14.02	16.79	2.77
7	10/15/2019	16.21	15.37	17.30	1.93
8	10/16/2019	15.69	14.72	16.86	2.14
9	10/17/2019	15.00	13.91	16.25	2.34
10	10/18/2019	15.02	13.91	16.26	2.35
11	10/19/2019	14.99	13.90	16.04	2.14
12	10/20/2019	16.04	15.26	17.04	1.78
13	10/21/2019	16.33	15.80	16.98	1.18
14	10/22/2019	14.82	14.07	15.80	1.73
*15	10/23/2019	13.50	12.86	14.54	1.68
Mean	15 days *Partial	15.70	14.69	16.79	2.10

Comments: Buried approximately 2 feet deep in gravel; wiper possibly lining up on sensor and not lining up after replacement

Temperature (°C)					
Station: Bryant Creek 2535 23.27, Douglas Co.			Location: below Rippee Creek		
Survey Period: 15 Days		Start: 10-09-2019		Stop: 10-23-2019	
				Observations: 2014	
Day	Date	Mean Daily Temperature	Minimum Daily Temperature	Maximum Daily Temperature	Change Daily Temperature
*1	10/09/2019	17.84	16.15	18.47	2.32
2	10/10/2019	18.08	17.49	18.72	1.23
3	10/11/2019	16.53	14.99	18.38	3.39
4	10/12/2019	14.91	13.65	16.08	2.43
5	10/13/2019	15.06	13.70	16.18	2.48
6	10/14/2019	15.33	13.89	16.39	2.50
7	10/15/2019	16.26	15.36	17.19	1.83
8	10/16/2019	15.61	14.57	16.63	2.06
9	10/17/2019	14.85	13.63	16.08	2.45
10	10/18/2019	14.93	13.74	16.20	2.46
11	10/19/2019	14.87	13.75	15.74	1.99
12	10/20/2019	16.06	15.25	17.06	1.81
13	10/21/2019	16.35	15.52	17.25	1.73
14	10/22/2019	14.64	13.71	15.52	1.81
*15	10/23/2019	13.20	12.58	14.09	1.51
Mean	15 days *Partial	15.63	14.53	16.67	2.14

Comments: Rocks may have stopped wiper on probe.

Specific Conductance (SpC; μS/cm)					
Station: Bryant Creek 2535 38.7, Douglas Co.			Location: 0.1 mile below Hwy U.		
Survey Period: 15 Days		Start: 10-09-2019		Stop:10-23-2019	Observations: 2007
Day	Date	Mean Daily SpC	Minimum Daily SpC	Maximum Daily SpC	Change Daily SpC
*1	10/09/2019	412.92	409.00	417.00	8.00
2	10/10/2019	415.81	400.00	420.00	20.00
3	10/11/2019	340.73	277.00	405.00	128.00
4	10/12/2019	393.37	377.00	402.00	25.00
5	10/13/2019	408.00	402.00	412.00	10.00
6	10/14/2019	413.31	411.00	416.00	5.00
7	10/15/2019	411.81	408.00	415.00	7.00
8	10/16/2019	410.28	407.00	413.00	6.00
9	10/17/2019	410.11	406.00	414.00	8.00
10	10/18/2019	408.85	404.00	413.00	9.00
11	10/19/2019	408.36	402.00	413.00	11.00
12	10/20/2019	408.72	402.00	413.00	11.00
13	10/21/2019	397.52	381.00	413.00	32.00
14	10/22/2019	408.68	405.00	412.00	7.00
*15	10/23/2019	415.30	412.00	418.00	6.00
Mean	15 days *Partial	404.25	393.53	413.07	19.53

Specific Conductance (SpC; μS/cm)					
Station: Bryant Creek 2535 35.2, Douglas Co.			Location: 0.1 mile above CR76-114		
Survey Period: 15 Days		Start: 10-09-2019		Stop:10-23-2019	Observations: 2009
Day	Date	Mean Daily SpC	Minimum Daily SpC	Maximum Daily SpC	Change Daily SpC
*1	10/09/2019	402.23	400.00	404.00	4.00
2	10/10/2019	403.14	392.00	405.00	13.00
3	10/11/2019	223.50	113.00	395.00	282.00
4	10/12/2019	229.94	219.00	241.00	22.00
5	10/13/2019	254.55	241.00	262.00	21.00
6	10/14/2019	265.97	262.00	269.00	7.00
7	10/15/2019	271.59	269.00	274.00	5.00
8	10/16/2019	274.90	274.00	276.00	2.00
9	10/17/2019	276.06	275.00	277.00	2.00
10	10/18/2019	276.61	276.00	277.00	1.00
11	10/19/2019	276.66	275.00	278.00	3.00
12	10/20/2019	277.25	275.00	278.00	3.00
13	10/21/2019	284.46	265.00	288.00	23.00
14	10/22/2019	285.26	283.00	287.00	4.00
*15	10/23/2019	284.79	283.00	286.00	3.00
Mean	15 days *Partial	285.79	273.47	299.80	26.33

Comments: Sonde was moved downstream by flood.

Specific Conductance (SpC; μS/cm)					
Station: Bryant Creek 2535 32.6, Douglas Co.			Location: above Hwy 76		
Survey Period: 15 Days		Start: 10-09-2019		Stop:10-23-2019	Observations: 2009
Day	Date	Mean Daily SpC	Minimum Daily SpC	Maximum Daily SpC	Change Daily SpC
*1	10/09/2019	411.25	409.00	413.00	4.00
2	10/10/2019	410.91	376.00	417.00	41.00
3	10/11/2019	282.81	174.00	386.00	212.00
4	10/12/2019	350.14	329.00	367.00	38.00
5	10/13/2019	374.99	367.00	386.00	19.00
6	10/14/2019	387.01	381.00	396.00	15.00
7	10/15/2019	392.25	380.00	401.00	21.00
8	10/16/2019	400.39	392.00	408.00	16.00
9	10/17/2019	402.66	392.00	409.00	17.00
10	10/18/2019	405.35	395.00	412.00	17.00
11	10/19/2019	404.68	396.00	412.00	16.00
12	10/20/2019	404.84	398.00	411.00	13.00
13	10/21/2019	390.74	357.00	408.00	51.00
14	10/22/2019	399.24	387.00	409.00	22.00
*15	10/23/2019	402.42	397.00	408.00	11.00
Mean	15 days *Partial	387.98	368.67	402.87	34.20

Comments: Wiper missing

Specific Conductance (SpC; μS/cm)					
Station: Bryant Creek 2535 27.6, Douglas Co.			Location: below CR 228		
Survey Period: 15 Days		Start: 10-09-2019		Stop:10-23-2019	Observations: 2011
Day	Date	Mean Daily SpC	Minimum Daily SpC	Maximum Daily SpC	Change Daily SpC
*1	10/09/2019	434.35	2.00	440.00	438.00
2	10/10/2019	437.11	415.00	443.00	28.00
3	10/11/2019	195.62	95.00	415.00	320.00
4	10/12/2019	244.38	221.00	258.00	37.00
5	10/13/2019	265.82	258.00	271.00	13.00
6	10/14/2019	274.62	271.00	278.00	7.00
7	10/15/2019	281.21	278.00	283.00	5.00
8	10/16/2019	284.49	282.00	286.00	4.00
9	10/17/2019	286.91	278.00	300.00	22.00
10	10/18/2019	284.41	283.00	285.00	2.00
11	10/19/2019	286.08	285.00	287.00	2.00
12	10/20/2019	286.13	279.00	289.00	10.00
13	10/21/2019	276.18	269.00	284.00	15.00
14	10/22/2019	283.43	281.00	288.00	7.00
*15	10/23/2019	285.77	283.00	289.00	6.00
Mean	15 days *Partial	293.77	252.00	313.07	61.07

Comments: Buried approximately 2 feet deep in gravel; wiper possibly lining up on sensor and not lining up after replacement.

Specific Conductance (SpC; $\mu\text{S}/\text{cm}$)					
Station: Bryant Creek 2535 23.27, Douglas Co.			Location: below Rippee Creek		
Survey Period: 15 Days		Start: 10-09-2019		Stop: 10-23-2019	
				Observations: 2014	
Day	Date	Mean Daily SpC	Minimum Daily SpC	Maximum Daily SpC	Change Daily SpC
*1	10/09/2019	430.16	429.00	432.00	3.00
2	10/10/2019	427.52	337.00	435.00	98.00
3	10/11/2019	212.62	121.00	405.00	284.00
4	10/12/2019	280.42	255.00	300.00	45.00
5	10/13/2019	320.92	300.00	356.00	56.00
6	10/14/2019	362.15	356.00	367.00	11.00
7	10/15/2019	371.24	367.00	375.00	8.00
8	10/16/2019	376.92	375.00	380.00	5.00
9	10/17/2019	381.62	380.00	384.00	4.00
10	10/18/2019	385.13	384.00	387.00	3.00
11	10/19/2019	387.87	387.00	389.00	2.00
12	10/20/2019	390.13	389.00	391.00	2.00
13	10/21/2019	378.70	374.00	393.00	19.00
14	10/22/2019	382.23	379.00	385.00	6.00
*15	10/23/2019	386.70	385.00	388.00	3.00
Mean	15 days *Partial	364.95	347.87	384.47	36.60

Comments: Rocks may have stopped wiper on probe

Turbidity (FNU)					
Station: Bryant Creek 2535 38.7, Douglas Co.			Location: 0.1 mile below Hwy U.		
Survey Period: 15 Days		Start: 10-09-2019		Stop:10-23-2019	Observations: 1989
Day	Date	Mean Daily Turbidity	Minimum Daily Turbidity	Maximum Daily Turbidity	Change Daily Turbidity
*1	10/09/2019	-0.6	-0.7	-0.6	0.1
2	10/10/2019	-0.6	-0.7	-0.2	0.5
3	10/11/2019	40.5	-0.1	185.9	186
4	10/12/2019	2.8	1.4	6.3	4.9
5	10/13/2019	1.0	0.5	3.7	3.2
6	10/14/2019	0.6	0.3	1.0	0.7
7	10/15/2019	0.9	0.6	1.4	0.8
8	10/16/2019	1.3	0.4	2.6	2.2
9	10/17/2019	4.1	1.5	20.3	18.8
10	10/18/2019	2.1	1.7	2.9	1.2
11	10/19/2019	2.4	1.2	3.4	2.2
12	10/20/2019	2.3	1.6	3.9	2.3
13	10/21/2019	3.3	2.2	5.7	3.5
14	10/22/2019	2.7	2.1	4.4	2.3
*15	10/23/2019	2.9	2.3	5.7	3.4
Mean	15 days *Partial	4.4	0.9	16.4	15.5

Comments: Erroneous readings were removed

Turbidity (FNU)					
Station: Bryant Creek 2535 35.2, Douglas Co.			Location: 0.1 mile above CR 76-114		
Survey Period: 15 Days		Start: 10-09-2019		Stop:10-23-2019	Observations: 1982
Day	Date	Mean Daily Turbidity	Minimum Daily Turbidity	Maximum Daily Turbidity	Change Daily Turbidity
*1	10/09/2019	-0.7	-0.8	-0.5	0.3
2	10/10/2019	-0.7	-0.8	0.3	1.1
3	10/11/2019	144.4	-0.4	1098.3	1098.7
4	10/12/2019	8.6	1.8	107.7	105.9
5	10/13/2019	1.3	0.6	4.5	3.9
6	10/14/2019	0.4	0.1	1.4	1.3
7	10/15/2019	0.2	-0.1	2.8	2.9
8	10/16/2019	0.0	-0.2	2.8	3
9	10/17/2019	-0.2	-0.3	0.1	0.4
10	10/18/2019	-0.2	-0.4	0.6	1
11	10/19/2019	-0.1	-0.4	4.2	4.6
12	10/20/2019	-0.3	-0.4	-0.1	0.3
13	10/21/2019	-0.1	-0.4	1.8	2.2
14	10/22/2019	-0.1	-0.3	1.0	1.3
*15	10/23/2019	0.1	-0.2	2.5	2.7
Mean	15 days *Partial	10.2	-0.1	81.8	82.0

Comments: Erroneous readings were removed; sonde was moved downstream by flood waters.

Turbidity (FNU)					
Station: Bryant Creek 2535 32.6, Douglas Co.			Location: above Hwy 76		
Survey Period: 15 Days		Start: 10-09-2019		Stop:10-23-2019	Observations: 2007
Day	Date	Mean Daily Turbidity	Minimum Daily Turbidity	Maximum Daily Turbidity	Change Daily Turbidity
*1	10/09/2019	0.7	0.5	0.9	0.4
2	10/10/2019	1.1	0.4	6.8	6.4
3	10/11/2019	44.3	3.9	243.3	239.4
4	10/12/2019	5.7	3.2	11.2	8
5	10/13/2019	2.8	1.8	4.6	2.8
6	10/14/2019	2.5	1.2	6.4	5.2
7	10/15/2019	2.4	0.9	4.8	3.9
8	10/16/2019	1.6	0.7	4.7	4
9	10/17/2019	0.9	0.5	1.7	1.2
10	10/18/2019	0.8	0.5	1.6	1.1
11	10/19/2019	0.7	0.4	1.3	0.9
12	10/20/2019	0.8	0.5	1.4	0.9
13	10/21/2019	4.0	0.6	16.6	16
14	10/22/2019	1.3	0.9	2.4	1.5
*15	10/23/2019	0.9	0.6	1.4	0.8
Mean	15 days *Partial	4.7	1.1	20.6	19.5

Comments: Erroneous readings were removed; wiper missing from sonde.

Turbidity (FNU)					
Station: Bryant Creek 2535 27.6, Douglas Co.			Location: below CR 228		
Survey Period: 15 Days		Start: 10-09-2019		Stop:10-23-2019	Observations: 360
Day	Date	Mean Daily Turbidity	Minimum Daily Turbidity	Maximum Daily Turbidity	Change Daily Turbidity
*1	10/09/2019	0.3	-0.1	2.5	2.6
2	10/10/2019	0.7	0.0	3.9	3.9
3	10/11/2019	326.1	2.1	892.7	890.6
4	10/12/2019	**	**	**	**
*15	10/23/2019	**	**	**	**
Mean	15 days *Partial	109.0	0.7	299.7	299.0

**Sonde was found buried on 10/23/2019. Erratic turbidity readings began on 10/12/2019, which was likely near the time the sonde was buried

Turbidity (FNU)					
Station: Bryant Creek 2535 23.27, Douglas Co.			Location: below Rippee Creek.		
Survey Period: 15 Days		Start: 10-09-2019		Stop: 10-23-2019	
				Observations: 491	
Day	Date	Mean Daily Turbidity	Minimum Turbidity	Maximum Turbidity	Δ Turbidity
*1	10/09/2019	1.1	0.7	1.7	1.0
2	10/10/2019	1.6	0.7	3.7	3.0
3	10/11/2019	122.1	4.5	485.7	481.2
4	10/12/2019	18.5	14.3	26.1	11.8
5	10/13/2019	**	**	**	**
*15	10/23/2019	**	**	**	**
Mean	15 days *Partial	35.8	5.1	129.3	124.3

**Upon retrieval, the sonde had a rock obstructing the wiper mechanism potentially blocking sensor; Erratic turbidity readings began on 10/13/2019, which was likely near the time this malfunction occurred.

Appendix B: ANOVA Comparisons – Sonde Turbidity Data at Bryant Creek Stations

One Way Analysis of Variance

Monday, September 16, 2024, 10:57:39 AM

Data source: Data 1 in Turbidity Test per Station

Normality Test: Failed (P < 0.050)

Equal Variance Test: Failed (P < 0.050)

Group Name	N	Missing	Mean	Std Dev	SEM
BC38.7	1989	0	4.682	16.674	0.374
BC35.2	1992	0	11.051	74.627	1.672
BC32.6	2007	0	5.001	17.400	0.388

Source of Variation	DF	SS	MS	F	P
Between Groups	2	51337.796	25668.898	12.543	<0.001
Residual	5985	12248344.656	2046.507		
Total	5987	12299682.451			

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

Power of performed test with alpha = 0.050: 0.997

All Pairwise Multiple Comparison Procedures (Holm-Sidak method):

Overall significance level = 0.05

Comparisons for factor:

Comparison	Diff of Means	t	Unadjusted P	Critical Level	Significant?
BC35.2 vs. BC38.7	6.369	4.441	0.00000911	0.017	Yes
BC35.2 vs. BC32.6	6.050	4.228	0.0000239	0.025	Yes
BC32.6 vs. BC38.7	0.319	0.223	0.824	0.050	No

One Way Analysis of Variance

Monday, September 16, 2024, 10:41:20 AM

Data source: Data 1 in Turbidity Test per Station**Normality Test:** Failed (P < 0.050)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks Monday, September 16, 2024, 10:41:20 AM**Data source:** Data 1 in Notebook 1

Group	N	Missing	Median	25%	75%
BC38.7 1989		0	2.000	0.800	2.800
BC35.2 1992		0	-0.1000	-0.200	0.600
BC32.6 2007		0	1.300	0.900	2.900

H = 1465.815 with 2 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	Q	P<0.05
BC38.7 vs BC35.2	1815.217	33.126	Yes
BC38.7 vs BC32.6	1.779	0.0325	No
BC32.6 vs BC35.2	1813.437	33.168	Yes

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Appendix C: ANOVA Comparisons – Fine Sediment Coverage at Bryant Creek Stations

One Way Analysis of Variance

Thursday, May 14, 2020, 12:55:09 PM

Data source: Data 1 in Fine Sed Data.SNB Fine Sediment Coverage per Station

Dependent Variable: Col 3

Normality Test: Failed (P < 0.050)

Equal Variance Test: Failed (P < 0.050)

Group Name	N	Missing	Mean	Std Dev	SEM
38.700	18	0	9.639	15.989	3.769
35.200	18	0	16.861	23.875	5.627
32.600	18	0	44.361	38.000	8.957
27.600	18	0	11.333	8.234	1.941
23.270	18	0	8.500	8.002	1.886

Source of Variation	DF	SS	MS	F	P
Between Groups	4	16212.806	4053.201	8.439	<0.001
Residual	85	40825.208	480.297		
Total	89	57038.014			

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

Power of performed test with alpha = 0.050: 0.997

All Pairwise Multiple Comparison Procedures (Holm-Sidak method):
Overall significance level = 0.05

Comparisons for factor: **Col 1 – Difference**

Comparison	Diff of Means	t	Unadjusted P	Critical Level	Significant?
32.600 vs. 23.270	35.861	4.909	0.00000437	0.005	Yes
32.600 vs. 38.700	34.722	4.753	0.00000808	0.006	Yes
32.600 vs. 27.600	33.028	4.521	0.0000198	0.006	Yes
32.600 vs. 35.200	27.500	3.764	0.000306	0.007	Yes
35.200 vs. 23.270	8.361	1.145	0.256	0.009	No
35.200 vs. 38.700	7.222	0.989	0.326	0.010	No
35.200 vs. 27.600	5.528	0.757	0.451	0.013	No
27.600 vs. 23.270	2.833	0.388	0.699	0.017	No
27.600 vs. 38.700	1.694	0.232	0.817	0.025	No
38.700 vs. 23.270	1.139	0.156	0.876	0.050	No

Kruskal-Wallis One Way Analysis of Variance on Ranks

Tuesday, August 20, 2019, 7:59:21 AM

Data source: Bryant Creek Sed Data.SNBDependent Variable: **Fine Sediment Coverage Col 3****Normality Test:** Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
38.700	18	0	2.750	0.500	12.500
35.200	18	0	7.500	5.000	13.500
32.600	18	0	28.750	6.500	89.500
27.600	18	0	10.500	4.500	15.000
23.270	18	0	7.000	3.000	10.000

H = 17.442 with 4 degrees of freedom. (P = 0.002)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.002)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparison	Diff of Ranks	q	P<0.05
32.6 vs 38.7	618.500	5.580	Yes
32.6 vs 23.27	481.500	4.344	Yes
32.6 vs 35.2	363.500	3.280	No
32.6 vs 27.6	306.500	2.765	Do Not Test
27.6 vs 38.7	312.000	2.815	No
27.6 vs 23.27	175.000	1.579	Do Not Test
27.6 vs 35.1	57.000	0.514	Do Not Test
35.1 vs 38.7	255.000	2.301	Do Not Test
35.1 vs 23.27	118.000	1.065	Do Not Test
23.27 vs 38.7	137.000	1.236	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

A result of "Do Not Test" occurs for a comparison when no significant difference is found between the two rank sums that enclose that comparison. For example, if you had four rank sums sorted in order, and found no significant difference between rank sums 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed rank sums is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the rank sums, even though one may appear to exist.

Two Way Analysis of Variance – Among Stations with Silt vs Sand
PM

Thursday, May 14, 2020, 12:32:45

Data source: Data 1 in Fine Sed Data.SNB [Factors = Stations; Silt (1) or Sand (2)]

General Linear Model

Dependent Variable: Col 3

Normality Test: Failed (P < 0.050)

Equal Variance Test: Failed (P < 0.050)

Source of Variation	DF	SS	MS	F	P
Col 1 (Stations)	4	7374.444	1843.611	6.139	<0.001
Col 5 (Silt v Sand)	1	955.606	955.606	3.182	0.078
Col 1 x Col 5	4	16793.995	4198.499	13.979	<0.001
Residual	80	24026.755	300.334		
Total	89	57038.014	640.877		

Main effects cannot be properly interpreted if significant interaction is determined. This is because the size of a factor's effect depends upon the level of the other factor.

The effect of different levels of Col 1 depends on what level of Col 5 is present. There is a statistically significant interaction between Col 1 and Col 5. (P = <0.001)

Power of performed test with alpha = 0.0500: for Col 1 : 0.966

Power of performed test with alpha = 0.0500: for Col 5 : 0.292

Power of performed test with alpha = 0.0500: for Col 1 x Col 5 : 1.000

Least square means for Col 1 : Stations

Group	Mean	SEM
38.700	24.453	6.499
35.200	32.250	5.480
32.600	36.542	4.333
27.600	14.031	6.499
23.270	8.500	4.560

Least square means for Col 5 : Silt (1) and Sand (2)

Group	Mean	SEM
1.000	18.727	2.389
2.000	27.583	4.352

Least square means for Col 1 x Col 5 : **Mean Silt (1) or Sand (2) percent coverage per Station (when observed)**

Group	Mean	SEM
38.700 x 1.000	5.406	4.333
38.700 x 2.000	43.500	12.254
35.200 x 1.000	9.167	4.475
35.200 x 2.000	55.333	10.006
32.600 x 1.000	60.000	5.003
32.600 x 2.000	13.083	7.075
27.600 x 1.000	10.562	4.333
27.600 x 2.000	17.500	12.254
23.270 x 1.000	8.500	7.750
23.270 x 2.000	8.500	4.807

All Pairwise Multiple Comparison Procedures (Holm-Sidak method):Overall significance level = 0.05 **Difference between silt (1) or sand (2) within a station**Comparisons for factor: **Col 5 within 38.7**

Comparison	Diff of Means	t	Unadjusted P	Critical Level	Significant?
2.000 vs. 1.000	38.094	2.931	0.004	0.050	Yes

Comparisons for factor: **Col 5 within 35.2**

Comparison	Diff of Means	t	Unadjusted P	Critical Level	Significant?
2.000 vs. 1.000	46.167	4.212	0.000	0.050	Yes

Comparisons for factor: **Col 5 within 32.6**

Comparison	Diff of Means	t	Unadjusted P	Critical Level	Significant?
1.000 vs. 2.000	46.917	5.414	0.000	0.050	Yes

Comparisons for factor: **Col 5 within 27.6**

Comparison	Diff of Means	t	Unadjusted P	Critical Level	Significant?
2.000 vs. 1.000	6.938	0.534	0.595	0.050	No

Comparisons for factor: **Col 5 within 23.27**

Comparison	Diff of Means	t	Unadjusted P	Critical Level	Significant?
2.000 vs. 1.000	1.776E-015	1.948E-016	1.000	0.050	No

Comparisons for factor: **Among Col 1 for 1 (silt) – Differences in percentage of silt (1) among stations**

Comparison	Diff of Means	t	Unadjusted P	Critical Level	Significant?
32.600 vs. 38.700	54.594	8.249	0.000	0.005	Yes
32.600 vs. 35.200	50.833	7.574	0.000	0.006	Yes
32.600 vs. 27.600	49.438	7.470	0.000	0.006	Yes
32.600 vs. 23.270	51.500	5.583	0.000	0.007	Yes
27.600 vs. 38.700	5.156	0.842	0.403	0.009	No
35.200 vs. 38.700	3.760	0.604	0.548	0.010	No
23.270 vs. 38.700	3.094	0.348	0.728	0.013	No
27.600 vs. 23.270	2.062	0.232	0.817	0.017	No
27.600 vs. 35.200	1.396	0.224	0.823	0.025	No
35.200 vs. 23.270	0.667	0.0745	0.941	0.050	No

Comparisons for factor: **Among Col 1 for 2 (sand) – Differences in percentage of sand (2) among stations**

Comparison	Diff of Means	t	Unadjusted P	Critical Level	Significant?
35.200 vs. 23.270	46.833	4.219	0.000	0.005	Yes
35.200 vs. 32.600	42.250	3.448	0.001	0.006	Yes
38.700 vs. 23.270	35.000	2.659	0.009	0.006	No
35.200 vs. 27.600	37.833	2.391	0.019	0.007	No
38.700 vs. 32.600	30.417	2.150	0.035	0.009	No
38.700 vs. 27.600	26.000	1.500	0.137	0.010	No
35.200 vs. 38.700	11.833	0.748	0.457	0.013	No
27.600 vs. 23.270	9.000	0.684	0.496	0.017	No
32.600 vs. 23.270	4.583	0.536	0.594	0.025	No
27.600 vs. 32.600	4.417	0.312	0.756	0.050	No

Appendix D

Macroinvertebrate Bench Sheet Report: Bryant Creek (WBID 2535) Stations, Douglas County, Missouri Fall 2019 – Spring 2021

**Grouped by season and stations (upstream to downstream)
CS = Course Substrate, NF = Non-Flow, RM = Rootmat**

Macroinvertebrate Bench Sheet Report			
Sep 18, 2019 Bryant Creek - 0.1 mi. bl. Hwy U [2535 38.7] - 19054			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	3	3	7
AMPHIPODA			
Hyalella azteca			12
BASOMMATOPHORA			
Ancylidae			2
BRANCHIOBDELLIDA			
Branchiobdellida			1
COLEOPTERA			
Dubiraphia		1	19
Enochrus			1
Helichus lithophilus		1	1
Heterosternuta			4
Microcylloepus pusillus			2
Optioservus sandersoni	114	14	1
Paracymus	1		
Psephenus herricki	55	28	2
Scirtidae			1
Stenelmis		1	
Tropisternus			2
DECAPODA			
Faxonius neglectus	*	*	
Faxonius punctimanus			1
DIPTERA			
Ablabesmyia		3	1
Anopheles			3
Chironomidae			
Chrysops		1	
Corynoneura		2	
Cricotopus/Orthocladius	2		7
Cryptochironomus	1	1	
Dicrotendipes			3
Forcipomyiinae	2		2
Hemerodromia			1
Hexatoma		*	
Labrundinia	1	1	1
Microtendipes		6	
Nilotanypus	1		

Parametriocnemus	3		
Paratendipes			1
Phaenopsectra		6	
Polypedilum aviceps	2		
Polypedilum flavum	85	1	1
Polypedilum illinoense grp			2
Polypedilum scalaenum grp			1
Rheocricotopus	1		
Rheotanytarsus	7		4
Simulium	3		
Stempellinella	4	9	2
Tabanus	1		
Tanytarsus	4	5	14
Thienemanniella	6	1	2
Thienemannimyia grp	19	3	12
Tribelos		1	
EPHEMEROPTERA			
Acentrella	1		
Acerpenna	5		
Anthopotamus		2	
Baetis	65		
Caenis anceps	43	21	7
Caenis latipennis	4	57	115
Centroptilum			1
Choroterpes		5	
Eurylophella	1		1
Isonychia bicolor	34		
Leptophlebiidae			2
Leucrocuta	15	4	
Procloeon		1	1
Stenacron		1	
Stenonema bednariki	1		
Stenonema femoratum		43	
Stenonema mediopunctatum	59	1	3
Stenonema pulchellum	68	16	3
Stenonema terminatum			3
Tricorythodes	72	16	1
HEMIPTERA			
Microvelia			8
Rhagovelia	1		
LUMBRICINA			

Lumbricina	2		
MEGALOPTERA			
Corydalus	1	*	
Nigronia serricornis		*	1
NEOTAENIOGLOSSA			
Elimia		4	
Hydrobiidae	3		
ODONATA			
Argia		3	
Calopteryx			9
Enallagma			2
Hagenius brevistylus		1	
PLECOPTERA			
Acroneuria		*	
Leuctra	4	2	
TRICHOPTERA			
Cheumatopsyche	61	1	
Helicopsyche	2	1	
Hydropsyche morosa grp	10	2	
Oecetis			1
Polycentropus	1	3	
Triaenodes			5
TRICLADIDA			
Planariidae	4		

Macroinvertebrate Bench Sheet Report			
Sep 18, 2019 Bryant Creek - 0.1 mi. ab. CR 76-114 [2535 35.2] - 19053			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	17	4	1
AMPHIPODA			
Hyalella azteca			1
Stygobromus		2	
BASOMMATOPHORA			
Physella		7	11
COLEOPTERA			
Dubiraphia			4
Gyrinus			4
Helichus lithophilus			2
Optioservus sandersoni	68	4	
Psephenus herricki	4		
Scirtidae			1
DECAPODA			
Faxonius neglectus	*		
Faxonius punctimanus			*
DIPTERA			
Ablabesmyia		7	1
Cardiocladius	4	1	
Ceratopogoninae	7	3	
Chironomidae	1		
Cladotanytarsus	5	55	1
Cricotopus bicinctus	6		1
Cricotopus trifascia	5		1
Cricotopus/Orthocladius	11	1	3
Cryptochironomus	4		
Dicrotendipes		38	6
Hemerodromia	12		1
Hexatoma	1	1	
Labrundinia		1	1
Micropsectra	84	67	113
Microtendipes	2	16	1
Nanocladius		1	
Nilotanypus	1	1	
Parametriocnemus	12	2	
Paratanytarsus	1	5	7
Phaenopsectra		11	

Polypedilum aviceps	32		6
Polypedilum flavum	21	1	1
Polypedilum illinoense grp		1	1
Polypedilum laetum		1	
Prosimulium	3		
Rheotanytarsus			11
Simulium	73		
Stempellinella	2	3	1
Stictochironomus		1	
Synorthocladius	11	2	2
Tabanus	*	*	
Tanytarsus	3	52	18
Thienemanniella	6		4
Thienemannimyia grp	13	27	12
Tipula			1
EPHEMEROPTERA			
Acentrella	4		10
Acerpenna	92	6	3
Baetis	351		2
Caenis anceps	17	18	2
Caenis latipennis	1	4	5
Centroptilum		1	3
Fallceon			2
Isonychia bicolor	79		2
Leptophlebiidae		4	1
Plauditus	178		3
Stenacron	2		
Stenonema femoratum		1	
Stenonema pulchellum	33	5	1
Tricorythodes	15	7	2
HEMIPTERA			
Belostoma			*
Microvelia			1
ISOPODA			
Lirceus	21	*	7
LUMBRICINA			
Lumbricina	*	1	
MEGALOPTERA			
Corydalus	6		
Nigronia serricornis	1		
ODONATA			
Basiaeschna janata			*

Calopteryx			9
Gomphidae	1		
Hagenius brevistylus			*
PLECOPTERA			
Acroneuria		*	
Leuctra	2	1	
Pteronarcys pictetii	*		
TRICHOPTERA			
Cheumatopsyche	666	1	6
Chimarra	1		
Helicopsyche	1		
Hydropsyche morosa grp	168		13
Hydroptila	3	6	13
Polycentropus		2	1
Protoptila	1		
Psychomyia			1
Pycnopsyche			*
TRICLADIDA			
Planariidae	1		

Macroinvertebrate Bench Sheet Report			
Sep 18, 2019 Bryant Creek - ab. Hwy 76 [2535 32.6] - 19052			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	7	4	6
AMPHIPODA			
Hyaella azteca			35
BASOMMATOPHORA			
Ancylidae		2	1
Menetus			1
Physella		2	3
COLEOPTERA			
Dubiraphia		9	8
Ectopria nervosa		2	3
Optioservus sandersoni	73	6	1
Psephenus herricki		4	
Scirtidae			3
Stenelmis	1		
DECAPODA			
Faxonius neglectus	*		*
Faxonius punctimanus			1
DIPTERA			
Ablabesmyia		1	11
Cardiocladius	2		
Ceratopogoninae	4	1	1
Chironomidae			2
Cladotanytarsus	4	4	10
Cricotopus/Orthocladius	3	3	
Cryptochironomus	3		20
Cryptotendipes		1	
Dicrotendipes		7	6
Endochironomus		1	
Hemerodromia	9		7
Hexatoma	1	*	
Labrundinia		1	
Micropsectra		1	1
Microtendipes		1	3
Nanocladius			1
Nilotanytus	2		
Nilothauma			1
Parametriocnemus	2		
Paratanytarsus		7	
Paratendipes			1
Phaenopsectra			6

Polypedilum flavum	66	1	1
Polypedilum illinoense grp		3	
Polypedilum scalaenum grp		1	1
Procladius		2	
Rheotanytarsus	3	17	1
Simulium	13		13
Stempellinella	1		10
Synorthocladius	1		
Tabanus	1		*
Tanytarsus		12	12
Thienemanniella	8	5	1
Thienemannimyia grp	3	19	18
Tipula			17
Zavrelimyia		1	
EPHEMEROPTERA			
Acentrella	8	1	
Anthopotamus		3	
Baetis	92		9
Caenis anceps	2	22	3
Caenis latipennis		188	55
Centroptilum			3
Ephemera simulans		*	
Heptageniidae	16	1	2
Hexagenia limbata		1	
Isonychia bicolor	13		2
Leucrocuta	1		
Plauditus	1		
Proclaeon		1	2
Stenacron		*	1
Stenonema femoratum		9	
Stenonema mediopunctatum	13	6	4
Stenonema pulchellum		1	2
Tricorythodes	37	64	7
HEMIPTERA			
Microvelia			1
LUMBRICINA			
Lumbricina	1	2	
MEGALOPTERA			
Corydalus	4		
NEOTAENIOGLOSSA			
Elimia		1	4
Leptoxis	1		
ODONATA			
Argia		8	

Basiaeschna janata			*
Enallagma			18
Gomphidae		2	
Hagenius brevistylus			*
Hetaerina			3
Progomphus obscurus		1	
PLECOPTERA			
Leuctra	1	1	
TRICHOPTERA			
Cheumatopsyche	161	1	17
Chimarra	5		2
Glossosoma	2		
Helicopsyche	2	1	
Hydropsyche morosa grp	33		6
Hydroptila			1
Oecetis		1	2
Orthotrichia	4		
Polycentropus		1	5
TRICLADIDA			
Planariidae	3		
TUBIFICIDA			
Limnodrilus hoffmeisteri		1	
Tubificinae		2	3
VENEROIDA			
Pisidiidae		1	

Macroinvertebrate Bench Sheet Report			
Sep 17, 2019 Bryant Creek - bl. CR 228 [2535_27.6] - 19051			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	4	5	
AMPHIPODA			
Hyaella azteca			3
BASOMMATOPHORA			
Ancylidae	1		
COLEOPTERA			
Dubiraphia		3	28
Ectopria nervosa	4	5	
Gyrinus			1
Helichus basalis			3
Helichus lithophilus			17
Optioservus sandersoni	236	16	4
Psephenus herricki	7	5	
Scirtidae			2
Stenelmis	17	2	
DECAPODA			
Faxonius neglectus	*		*
DIPTERA			
Ablabesmyia		6	
Chrysops			1
Cladotanytarsus	1	25	
Cricotopus/Orthocladius	2	3	8
Cryptochironomus	2	10	
Cryptotendipes		3	
Dicrotendipes		17	4
Dixidae			1
Forcipomyiinae			1
Hemerodromia	3		9
Hexatoma	1	1	
Labrundinia		1	
Microtendipes	1	9	1
Nanocladius		1	
Paralauterborniella		1	
Parametriocnemus	2		
Paratanytarsus		1	1
Phaenopsectra		37	
Polypedilum flavum	22	25	3
Polypedilum illinoense grp			5
Polypedilum laetum		3	
Polypedilum scalaenum grp		4	

Rheotanytarsus	2	3	46
Simulium	4	1	63
Stempellina		3	
Stempellinella		42	
Synorthocladius		2	
Tabanus	1	*	
Tanytarsus	1	13	8
Thienemanniella		3	2
Thienemannimyia grp	1	3	3
EPHEMEROPTERA			
Acentrella	7		1
Anthopotamus		14	1
Baetis	48		23
Caenis anceps		4	3
Caenis latipennis		9	7
Centroptilum		1	1
Ephemera simulans		2	
Isonychia bicolor	14		2
Labiobaetis			2
Plauditus	4		2
Procladius		5	1
Serratella			1
Stenacron		3	
Stenonema femoratum		6	
Stenonema mediopunctatum	36		2
Stenonema pulchellum	10		*
Tricorythodes	62	10	11
ISOPODA			
Caecidotea (Blind & Unpigmented)		1	
LUMBRICINA			
Lumbricina	2		
MEGALOPTERA			
Corydalus	2	*	1
NEOTAENIOGLOSSA			
Elimia	10	25	5
Hydrobiidae			
Leptoxis	7		
Pleurocera	1	1	
ODONATA			
Dromogomphus			*
Hetaerina			9
Macromia			*
PLECOPTERA			
Leuctra	1	1	

TRICHOPTERA			
Agapetus	7		
Cheumatopsyche	129		42
Helicopsyche	5	2	
Hydropsyche morosa grp	20		13
Hydroptila	1		1
Mystacides		3	2
Nectopsyche diarina			1
Ochrotrichia		2	
Oecetis		4	3
Polycentropus	1		2
Protoptila	8		
Triaenodes			5
TUBIFICIDA			
Tubificinae		2	

Macroinvertebrate Bench Sheet Report			
Sep 17, 2019 Bryant Creek - bl. Rippee Creek [2535 23.27] - 19050			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	4		50
AMPHIPODA			
Hyaella azteca			49
BASOMMATOPHORA			
Ancylidae	1	4	2
COLEOPTERA			
Ancyronyx variegatus			1
Berosus			1
Dubiraphia		16	51
Ectopria nervosa	1	11	
Helichus lithophilus			9
Heterosternuta			1
Macronychus glabratus			4
Microcylloepus pusillus			2
Optioservus sandersoni	80	13	4
Psephenus herricki	4	3	
Scirtidae			3
Stenelmis	18	20	
DECAPODA			
Faxonius neglectus	2		1
Faxonius punctimanus			*
DIPTERA			
Ablabesmyia		10	7
Anopheles			1
Cardiocladius	1		
Ceratopogoninae		2	2
Chironomus		5	
Cladotanytarsus	1	2	1
Cricotopus bicinctus	1		
Cricotopus/Orthocladius	2		12
Cryptochironomus	3	7	2
Cryptotendipes		17	1
Dicrotendipes		14	1
Dixella			1
Empididae (undescribed)		1	
Forcipomyiinae			1
Hemerodromia	1		
Labrundinia			1
Limnophila	1		
Micropsectra	1		

Microtendipes	3	3	
Nanocladius		1	
Nilothauma			1
Parakiefferiella			1
Paralauterborniella		4	2
Paratanytarsus			3
Phaenopsectra		2	
Polypedilum fallax grp			1
Polypedilum flavum	16	2	
Polypedilum halterale grp		1	
Polypedilum illinoense grp			6
Polypedilum scalaenum grp		7	
Rheotanytarsus	16	1	
Simulium	4		
Stempellina		2	
Stempellinella		9	5
Synorthocladius	1		
Tabanus	2		
Tanytarsus	3	7	11
Thienemanniella	1		
Thienemannimyia grp	1		3
EPHEMEROPTERA			
Acentrella	4		
Anthopotamus	5	38	
Baetis	7		
Baetisca lacustris		1	
Caenis anceps	20	13	
Caenis latipennis		35	6
Centroptilum		2	1
Ephemera simulans	1	5	
Heptageniidae	16	3	
Isonychia bicolor	68		
Leptophlebiidae		2	3
Leucrocuta	3		
Proclueon	1	3	1
Stenacron	3	2	
Stenonema femoratum		22	
Stenonema mediopunctatum	124	5	
Stenonema pulchellum	25		4
Tricorythodes	43	16	14
HEMIPTERA			
Microvelia			1
MEGALOPTERA			
Corydalus	26		

NEOTAENIOGLOSSA			
Elimia	3	7	
Leptoxis		4	1
Pleurocera		8	*
ODONATA			
Argia		2	3
Basiaeschna janata			*
Calopteryx			4
Enallagma			17
Macromia		*	1
Stylogomphus albistylus			*
PLECOPTERA			
Acroneuria	1		
Chloroperlidae		1	
Leuctra	4		
TRICHOPTERA			
Cheumatopsyche	119		
Chimarra		1	
Helicopsyche	5	1	
Hydropsyche morosa grp	17		
Hydroptila		1	
Nectopsyche		1	
Oecetis		1	12
Polycentropus			7
Protoptila	5		
Trienodes			10
TUBIFICIDA			
Limnodrilus hoffmeisteri		2	
Tubificinae	6	2	2
VENEROIDA			
Corbicula		1	

Macroinvertebrate Bench Sheet Report			
Apr 14, 2021 Bryant Creek - 0.1 mi. bl. Hwy U [2535 38.7] - 21026			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	3	14	1
COLEOPTERA			
Dubiraphia			1
Dytiscidae		3	
Optioservus sandersoni	63	15	2
Psephenus herricki	1		
Stenelmis	4	2	
DECAPODA			
Faxonius neglectus	1		*
DIPTERA			
Ceratopogoninae	2	6	
Chironomus	1	3	
Cladotanytarsus		2	1
Clinocera	1		
Corynoneura		1	
Cricotopus/Orthocladius	85	136	61
Cryptochironomus		1	1
Demicryptochironomus		1	
Dicrotendipes		1	3
Eukiefferiella	36	6	28
Gonomyia		5	
Hemerodromia	2	2	2
Hexatoma	4	1	
Limoniidae	1	1	
Micropsectra	9	5	4
Microtendipes		1	
Nilotanytus		3	
Parakiefferiella		3	
Parametriocnemus	1	1	
Paratendipes		1	
Polypedilum flavum	19	2	6
Polypedilum scalaenum grp	2		
Polypedilum tritum		1	
Prosimulium			1
Simulium	4		6
Stempellinella	1	1	
Sympotthastia	4	4	2
Synorthocladius	4		
Tabanus	1	*	*
Tanytarsus		8	2

Thienemanniella			1
Thienemannimyia grp	20	19	4
Tvetenia bavarica grp			1
EPHEMEROPTERA			
Acentrella	41	9	5
Acerpenna	10		1
Anafroptilum			1
Baetis	4		2
Caenis latipennis	24	67	38
Dannella		2	
Ephemerella invaria	13		1
Eurylophella bicolor	30	60	35
Eurylophella enoensis			10
Isonychia bicolor	4		1
Leucrocuta	37	2	
Plauditus	50	8	7
Rhithrogena	13		
Stenonema femoratum		*	
Stenonema mediopunctatum	10	2	
Stenonema pulchellum	42	4	3
Stenonema terminatum	1		
Teloganopsis deficiens	2		
LUMBRICINA			
Lumbricina	2		
MEGALOPTERA			
Corydalus	1		
Nigronia serricornis		1	
NEOTAENIOGLOSSA			
Elimia	4		8
ODONATA			
Calopteryx			1
Gomphidae	1		
PLECOPTERA			
Acroneuria	*		
Amphinemura	26		21
Chloroperlidae	3	1	
Isoperla	30	2	7
Leuctridae	11	2	
Perlesta	54	7	43
Pteronarcys pictetii	1		
Zealeuctra	2		
TRICHOPTERA			
Cheumatopsyche	13		2
Chimarra	1		
Helicopsyche	1	3	

Hydropsyche slossonae	1		*
Ironoquia			*
Lepidostoma	1		
Mystacides			1
Ochrotrichia			1
Plectrocnemia		*	*
Protoptila	4		
Rhyacophila	1		
TUBIFICIDA			
Enchytraeidae	1		
Tubificinae		1	

Macroinvertebrate Bench Sheet Report			
Apr 14, 2021 Bryant Creek - 0.1 mi. ab. CR 76-114 [2535_35.2] - 21025			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	4		
AMPHIPODA			
Hyaella azteca			1
BASOMMATOPHORA			
Physella		*	2
COLEOPTERA			
Agabus			1
Dytiscidae	2	2	1
Optioservus sandersoni	6		1
DIPTERA			
Ablabesmyia			1
Ceratopogoninae	5	9	
Chironomus			3
Cladotanytarsus		2	
Clinocera	5	1	
Cricotopus/Orthocladius	123	137	75
Dicrotendipes		10	2
Diptera		1	
Empididae (undescribed)		1	
Eukiefferiella	99	22	57
Hemerodromia	1	1	
Hexatoma	*	1	
Limoniidae	1		
Microtendipes		1	
Parametriocnemus	1	1	
Paratanytarsus			7
Polypedilum flavum	9		
Rheotanytarsus			1
Simulium	6		
Stempellinella		1	
Stictochironomus		3	2
Synorthocladius	1	2	1
Tanytarsus	16	35	12
Thienemannimyia grp	14	4	3
Zavrelimyia			1
EPHEMEROPTERA			
Acentrella	193	2	8
Acerpenna	1		
Anafroptilum		2	4
Anthopotamus		*	

Baetis	9		2
Caenis latipennis	1	5	
Dipheter	1		
Ephemerella invaria	6		
Eurylophella bicolor	3	6	19
Heptageniidae	4	1	
Isonychia bicolor	2		
Leptophlebiidae	2		1
Leucrocuta	11	2	1
Paraleptophlebia	3		
Plauditus	62		27
Rhithrogena	8		
Siphonurus			*
Stenonema femoratum	1	*	
Stenonema mediopunctatum	4		
Stenonema pulchellum	6		*
ISOPODA			
Lirceus	12		5
MEGALOPTERA			
Corydalus	1		
NEOTAENIOGLOSSA			
Elimia			*
ODONATA			
Calopteryx			*
PLECOPTERA			
Alloperla	*		
Amphinemura	32		21
Isoperla	24	*	5
Perlesta	31		7
Zealeuctra	42	2	2
TRICHOPTERA			
Cheumatopsyche	*		1
Ironoquia			*
Ochrotrichia			3
Plectrocnemia	1		*
Pycnopsyche			1
Rhyacophila	2		
TRICLADIDA			
Planariidae	1		
TUBIFICIDA			
Enchytraeidae	1	3	

Macroinvertebrate Bench Sheet Report			
Apr 14, 2021 Bryant Creek - ab. Hwy 76 [2535 32.6] - 21024			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	5	1	
AMPHIPODA			
Hyaella azteca			1
Stygobromus	1		
BRANCHIOBELLELLIDA			
Branchiobdellida			1
COLEOPTERA			
Dubiraphia	1	2	1
Optioservus sandersoni	12	11	1
Psephenus herricki		1	
Stenelmis	1	1	
DECAPODA			
Faxonius virilis			*
DIPTERA			
Ablabesmyia		1	
Cardiocladius			1
Ceratopogoninae	1	9	
Chironomus		1	
Cladotanytarsus		20	
Clinocera	1	1	
Cricotopus bicinctus	1		2
Cricotopus/Orthocladius	24	115	16
Cryptochironomus		1	
Demicryptochironomus	1	1	
Dicrotendipes		9	2
Eukiefferiella	54	19	32
Hemerodromia	2	1	1
Hexatoma	1	2	
Micropsectra	7	6	1
Microtendipes		1	
Nilothauma		1	
Parakiefferiella		5	
Parametriocnemus	4	1	
Paratanytarsus			1
Paratendipes		2	
Polypedilum aviceps	1		
Polypedilum flavum	5	9	1
Polypedilum laetum		4	
Potthastia		11	
Rheotanytarsus			1

Simulium	10		3
Stempellinella	2	1	
Stictochironomus		12	
Synorthocladius	3	2	
Tabanus	2		*
Thienemanniella			2
Thienemannimyia grp	2	11	2
Tvetenia bavarica grp	3		3
EPHEMEROPTERA			
Acentrella	238	3	69
Acerpenna	4		
Anthopotamus		4	
Baetis	53	2	2
Caenis latipennis		47	7
Ephemerella invaria	8		4
Eurylophella bicolor		3	11
Isonychia bicolor	8		1
Leptophlebiidae	2	1	
Leucrocota	11	1	
Plauditus	26		28
Rhithrogena	23		
Stenacron		6	
Stenonema femoratum	*	3	
Stenonema mediopunctatum	5	1	
ISOPODA			
Lirceus	4	1	10
LUMBRICULIDA			
Lumbriculidae		1	
MEGALOPTERA			
Corydalus	*		
NEOTAENIOGLOSSA			
Elimia			14
ODONATA			
Argia		1	
Calopteryx			1
Hetaerina			2
PLECOPTERA			
Acroneuria	*		
Amphinemura	79		15
Isoperla	18		
Perlesta	46	3	17
Pteronarcys pictetii	1		
Zealeuctra	4	3	
TRICHOPTERA			

Cheumatopsyche	2		4
Hydroptila	1		1
Ochrotrichia			12
Oecetis			5
Plectrocnemia		1	
Pycnopsyche			1
Rhyacophila	1		
Trienodes			3
TRICLADIDA			
Planariidae	1		
TUBIFICIDA			
Enchytraeidae	1		
Limnodrilus hoffmeisteri		2	
Tubificinae		4	2

Macroinvertebrate Bench Sheet Report			
Apr 15, 2021 Bryant Creek - bl. CR 228 [2535 27.6] - 21027			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	6	13	
AMPHIPODA			
Hyalella azteca			4
BRANCHIOBELLELLIDA			
Branchiobdellida			1
COLEOPTERA			
Dubiraphia			4
Dytiscidae		1	
Optioservus sandersoni	68	37	4
Psephenus herricki	6	1	
Stenelmis	83	11	6
DECAPODA			
Faxonius neglectus			*
DIPTERA			
Ablabesmyia	2	1	
Antocha	1		
Ceratopogoninae	5	8	
Cladotanytarsus	1	15	1
Cricotopus/Orthocladius	42	75	39
Cryptochironomus		4	
Dicortendipes		1	
Empididae (undescribed)	1		
Eukiefferiella	43	4	63
Hemerodromia	9	3	4
Hexatoma	53	6	1
Nilotanytus			1
Nilothauma		1	
Parakiefferiella		2	
Paratanytarsus			1
Polypedilum flavum	13	21	1
Polypedilum halterale grp	3	7	
Polypedilum laetum		2	2
Polypedilum scalaenum grp		3	
Rheotanytarsus			1
Robackia		1	
Simulium	5		2
Stempellinella		1	
Symptothastia	4	11	3
Synorthocladius	2	3	1
Tabanus	1	*	*

Tanytarsus	4	11	1
Thienemannimyia grp	1	6	6
EPHEMEROPTERA			
Acentrella	53	21	10
Acerpenna	5		
Anthopotamus		7	
Baetis	13	1	1
Caenis latipennis	7	34	28
Ephemerella invaria	8	2	8
Ephemerella needhami			1
Eurylophella bicolor	2	9	14
Eurylophella enoensis			3
Isonychia bicolor	4		5
Leucrocota	2	4	
Paraleptophlebia	1	2	3
Plautidius		2	10
Rhithrogena	29		
Stenacron		2	
Stenonema femoratum		7	
Stenonema mediopunctatum	11	1	1
Stenonema pulchellum	17		1
Stenonema terminatum	1	2	2
Teloganopsis deficiens	4		8
LUMBRICINA			
Lumbricina	5		
MEGALOPTERA			
Corydalus	*		
NEOTAENIOGLOSSA			
Elimia			9
Pleurocera			5
ODONATA			
Basiaeschna janata			*
Calopteryx			*
Macromia			*
PLECOPTERA			
Acroneuria	*		
Alloperla	14	4	
Amphinemura	14		17
Isoperla	8	1	13
Neoperla		1	1
Perlesta	13	4	14
Pteronarcys pictetii			1
TRICHOPTERA			
Cheumatopsyche	8	2	7
Glossosoma	11		

Nectopsyche		1	2
Ochrotrichia		1	
Oecetis			2
Oxyethira			1
Polycentropodidae			1
Pycnopsyche			*
TRICLADIDA			
Planariidae			1

Macroinvertebrate Bench Sheet Report			
Apr 14, 2021 Bryant Creek - bl. Rippee Creek [2535 23.27] - 21091			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	4	3	8
AMPHIPODA			
Gammarus	1		
Hyaella azteca			9
BASOMMATOPHORA			
Gyraulid		1	
COLEOPTERA			
Ancyronyx variegatus			3
Dubiraphia		19	9
Ectopria nervosa			1
Macronychus glabratus			3
Optioservus sandersoni	77	22	5
Psephenus herricki	4		2
Stenelmis	44	8	10
DECAPODA			
Faxonius neglectus	*	*	*
DIPTERA			
Ablabesmyia		1	4
Cardiocladius	4		
Ceratopogoninae	2	2	1
Chironomidae	4	2	6
Cladotanytarsus	1	53	3
Clinocera	2	1	
Cricotopus/Orthocladius	56	26	17
Cryptochironomus	1	9	1
Dicortendipes		6	9
Eukiefferiella	57	1	1
Gonomyia	4		
Hemerodromia	13	2	4
Hexatoma	2	2	
Micropsectra	6	1	2
Nilothauma		1	
Parakiefferiella		9	
Paralauterborniella		2	
Paratanytarsus			3
Paratendipes			1
Phaenopsectra		2	1
Polypedilum fallax grp		3	
Polypedilum flavum	22	10	2
Potthastia	3	1	3

Prosimulium	1		
Protoplasma fitchii	*		
Rheotanytarsus			2
Robackia	1		
Simulium	22		1
Stempellina		1	
Stempellinella		4	
Synorthocladius	1		
Tabanus	1		1
Tanytarsus	2	8	8
Thienemanniella			1
Thienemannimyia grp	1	12	13
EPHEMEROPTERA			
Acentrella	7		
Acerpenna	1		
Anafroptilum		1	2
Anthopotamus	1	28	1
Baetis	8		
Baetisca lacustris			1
Caenis latipennis	6	68	65
Ephemera simulans		*	1
Ephemerella invaria	23	1	1
Eurylophella bicolor	1	11	10
Isonychia bicolor	21		1
Leucrocota	1		
Plauditus	30	1	3
Rhithrogena	39	1	
Stenacron	1	1	
Stenonema	4		
Stenonema femoratum		2	4
Stenonema mediopunctatum	37	1	
Stenonema pulchellum	45	4	3
Stenonema terminatum			1
Teloganopsis deficiens	21		7
LUMBRICINA			
Lumbricina	4		
MEGALOPTERA			
Corydalus	5		
Nigronia serricornis			1
NEOTAENIOGLOSSA			
Elimia		2	
Pleurocera			1
ODONATA			
Basiaeschna janata			1
Calopteryx			*

Dromogomphus			*
Enallagma			10
Epitheca (Tetragoneuria)			*
Hagenius brevistylus			*
Macromia			*
PLECOPTERA			
Acroneuria	1		
Alloperla	1	1	
Amphinemura	14		24
Isoperla	3		1
Perlesta	50	2	22
Pteronarcys pictetii	1		1
Zealeuctra	12	2	
TRICHOPTERA			
Cheumatopsyche	14		7
Chimarra	1		
Helicopsyche	2		
Hydropsyche morosa grp	5		
Nectopsyche			1
Oecetis		2	1
Polycentropus			4
Proptila	3	1	
Pycnopsyche			*
Triaenodes			2
TUBIFICIDA			
Branchiura sowerbyi		1	
Tubificinae		3	3

